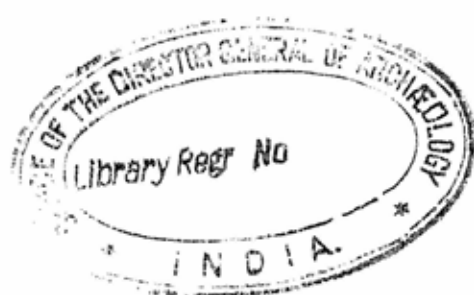


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ANNUAL REPORT

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*BOARD OF SCIENTIFIC ADVICE
FOR INDIA*

FOR THE YEAR

1904-05.

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PREFACE.

THE Board of Scientific Advice for India was constituted in 1902, and consisted originally of the heads of the Meteorological, Geological, Botanical, Forest, Survey, Agricultural and Veterinary Departments; but the Government of India intimated their intention to invite from time to time to serve upon it other scientific officers in the service of the Imperial and Provincial Governments, whose special attainments might render their assistance desirable. The Board was declared to be a central authority for the co-ordination of official scientific enquiry, its object being to ensure that the work of research is distributed to the best advantage, that each investigator confines his researches to the subject with which he is most capable of dealing, and that energy is not dissipated by the useless duplication of enquiries or misdirected by a lack of inter-departmental co-operation. It was also hoped that while the claims of abstract science would continue to be recognized in the work of the scientific departments, the Board's advice would aid the Government of India in prosecuting practical research into those questions of economic or applied science, on the solution of which the progressive prosperity of the country, especially as regards its agricultural and industrial development, so largely depends.

The Board advises generally upon the operations of the Departments, with due attention to the economic side of their work, and serves as a reference on all matters connected with the organization of scientific enquiry in India. It annually discusses the proposals of each departmental head in regard to the programme of investigation in his department; and in cases where inter-departmental co-operation is necessary, it advises as to the lines on which mutual assistance should be given and the department to which the enquiry should primarily appertain. It submits annually to the Government a general programme of research, embodying the proposals of departmental heads in so far as its subjects are to be exclusively dealt with in one department, and its own proposals in cases where two or more departments are to co-operate.

And at the end of the year it presents a brief review of the results obtained during the year in all lines of scientific investigation controlled by its members. Its reports and programmes are communicated through the Secretary of State to the Royal Society, who have appointed an Advisory Committee to consider them, and who from time to time furnish the Board and the Government of India with valuable suggestions and advice.

The present members of the Board of Scientific Advice are :

Appointment.	Name.
Secretary to the Government of India in the Department of Revenue and Agriculture. <i>Ex-officio</i> President.	Mr. J. WILSON, M.A., C.S.I., I.C.S.
Surveyor-General of India	Colonel F. B. LONGE, R.E.,
Meteorological Reporter to the Government of India and Director-General of Indian Observatories.	Dr. GILBERT T. WALKER, M.A., Sc. D., F.R.S.
Director, Geological Survey of India	Mr. T. H. HOLLAND, F.G.S., F.R.S., A.R.C.S.
Director, Botanical Survey of India	Captain A. T. GAGE, I.M.S., M.A., M.B., B.Sc., F.L.S., Officiating.
Superintendent, Natural History Section, Indian Museum.	Lt.-Col. A. W. ALCOCK, I.M.S., C.I.E., M.B., LL.D., F.L.S., C.M.Z.S., F.R.S.
Inspector-General of Forests	Mr. S. EARDLEY-WILMOT.
Inspector-General of Agriculture	Mr. F. G. SLY, I.C.S., Officiating.
Inspector-General, Civil Veterinary Department.	Colonel J. W. A. MORGAN, M.R.C.V.S.
Reporter on Economic Products to the Government of India.	Mr. I. H. BURKILL, M.A., F.L.S., Officiating.

List of Sub-Committees of the Board of Scientific Advice.

Sub-Committee A.—(Meteorology, Terrestrial Magnetism and cognate subjects).

1. The Surveyor-General of India (Chairman) ;
2. The Meteorological Reporter to the Government of India ;
3. The Director, Geological Survey of India.

Sub-Committee B.—(Agricultural Products).

1. The Director, Botanical Survey of India, (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Inspector-General of Agriculture.

Sub-Committee C.—(Soils and Manures).

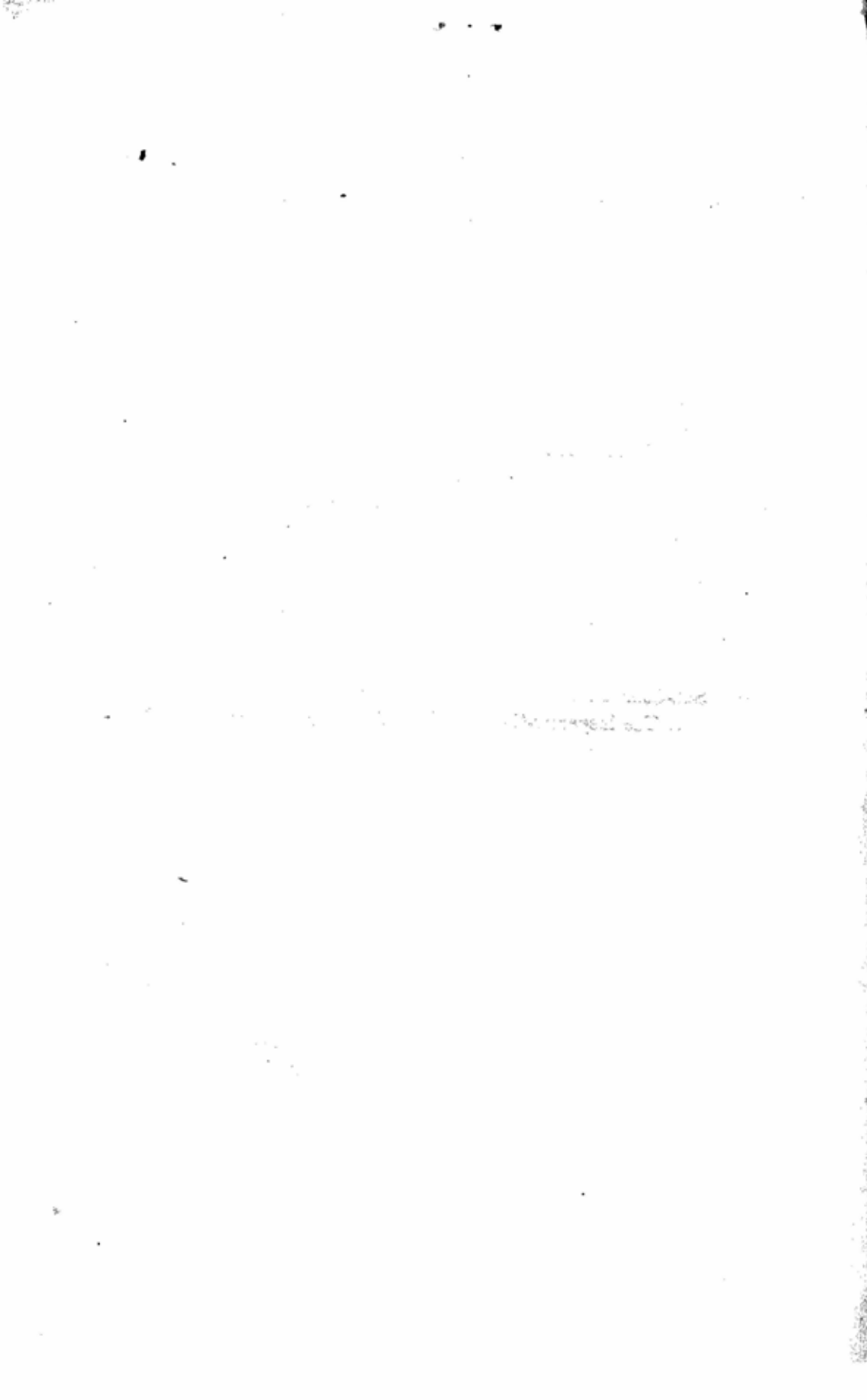
1. The Inspector-General of Agriculture (Chairman) ;
2. The Director, Geological Survey of India ;
3. The Inspector-General of Forests.

Sub-Committee D.—(Forest Products).

1. The Inspector-General of Forests (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(Veterinary subjects).

1. The Inspector-General, Civil Veterinary Department (Chairman) ;
2. The Inspector-General of Agriculture in India ;
3. The Superintendent, Natural History Section, Indian Museum.



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ANNUAL REPORT
OF THE
BOARD OF SCIENTIFIC ADVICE
FOR INDIA
FOR
1904-05.

SUMMARY OF PROCEEDINGS.

1st Meeting held at Calcutta on 6th February 1903.

IT was recommended that the Superintendent of the Industrial Section of the Indian Museum should be appointed a member of the Board.

The Board approved Major Prain's suggestion that the co-operation of the Forest Department should be invited in collecting timber specimens of the species of Indian trees desired by Mr. Gamble for study in connection with his "Manual of Indian Timbers," the timber specimens to be of a size large enough to admit of a duplicate sample being prepared for the Industrial Section of the Indian Museum, and to be accompanied by botanical specimens taken from the actual tree that yielded the timber specimens, and that the specimens should be sent to the Director of the Botanical Survey for identification.

A note by Mr. Mollison, Inspector-General of Agriculture, on the improvement of cotton fibre and on the cotton-seed oil industry was referred to a sub-committee for report.

A note by Mr. W. H. Moreland, Director of Land Records and Agriculture, United Provinces of Agra and Oudh, was read, in which he stated (a) that information was needed on the nature and efficiency of the soil micro-organisms in respect to the fixation of nitrogen; (b) that in order to develop the *ghi* industry of Bundelkhand it was desirable to know the flavouring constituents of the various forms of *ghi*, and how the flavour could be regulated; (c) that it appeared desirable that a systematic study should be made of the species of Agave which flourish in India, in order to determine whether any by-products could be prepared from the remains of the plant after its fibre had been extracted, without affecting the fibre. The Board recognised the importance of the first matter mentioned by Mr. Moreland, and asked the Inspector-General of Agriculture to report how far his Department could undertake the investigation. They considered that the investigation into the flavouring constituents of *ghi* could be more appropriately undertaken locally. With regard to the Agave question, they were informed that the systematic study of the species was in hand.

The Reports and Programmes of the Scientific Departments represented on the Board were then considered. With regard to Reports, the general feeling of the Board was that a brief summary of the results obtained in all lines of scientific investigation, based upon the annual departmental Reports and upon papers published by individuals, would suffice. With regard to Programmes, the Board resolved that the head of each department represented on the Board should furnish the Secretary of the Board with a memorandum of the more important questions to be dealt with by his department during the year, and that from these memoranda the Secretary should prepare a programme to be laid before the Board for submission to Government.

2nd Meeting held at Calcutta on 23rd March 1903.

Major Prain was nominated as Secretary.

The Board considered the Report of its sub-committee on the notes of the Inspector-General of Agriculture on (a) the improvement of cotton fibre, (b) the cotton-seed oil industry. As regards (a) the sub-committee recognised the necessity of undertaking a survey of the

species, varieties, races, hybrids and crosses of cotton at present cultivated in India, and recommended that the Reporter on Economic Products, working in conjunction with the Director of the Botanical Survey, should be invited to publish the results of the investigation conducted by his department, after visiting every cotton-producing area to procure the necessary material. They also emphasised the importance of establishing experimental stations for the production of improved seed, and accepted Mr. Mollison's scheme for such a station at Hissar. They were of opinion that the officer in charge of each such station should be an expert in the science of selecting and maturing seed, and that experts would have to be brought from England. With regard to Mr. Mollison's note on the cotton-seed oil industry, the sub-committee recommended that it should be published as an Agricultural Ledger, that a few small consignments of Indian cotton seed from some of the important cotton-growing Provinces should be sent to America for trial in American mills, and that arrangements should be made to obtain a report on the trial from an officer of the United States Department of Agriculture. These recommendations were accepted by the Board.

The Board passed the draft Annual Report for the preceding year.

They then considered the draft programmes of scientific work for the various departments for 1903-04. With reference to those programmes they considered that the preparation of a botanical manual of Indian cultivated plants should be omitted from the programme of the Reporter on Economic Products, as the preparation of such a manual falls more properly to the Botanical Department. They resolved that the question of famine foods mentioned in the programmes, both of the Reporter on Economic Products and the Inspector-General of Agriculture, should be referred to the sub-committee on Agricultural Products before further action was taken. They further resolved that the investigations regarding rubber, cassava cultivation, the production of tapioca flour and the plantain-fibre industry, mentioned in the programme of the Inspector-General of Agriculture, should be referred to the sub-committees concerned for recommendation as to how far the enquiries should be carried on by the different departments. With reference to the programme of the Director of the Geological Survey, they called attention

to the necessity for a revision of the topographical maps of the Jherria and Raniganj coal-fields, and the Director of the Geological Survey was asked to prepare a memorandum stating the reasons for such revision.

The Board resolved that permanent sub-committees should be appointed to deal with special questions as they arose, and that each sub-committee should be empowered to call upon any other member of the Board to join it should it consider his advice on any particular subject desirable.

The Board considered a Despatch from the Secretary of State for India on the subject of the Report of the Imperial Institute, Indian Section, for 1901-02, and referred it for report to a sub-committee.

Two questions were brought forward by the Director of the Botanical Survey, *vis.*, (1) the state of our knowledge of the sources of the various fibres that are used in and are exported from India, (2) the possibility of creating an industry in connection with the extraction of the fibre contained in the flax plant. The Board referred both questions for report to a sub-committee and asked the Reporter on Economic Products to assist in collecting seeds of various fibre plants for experimental cultivation.

The Director of the Geological Survey placed before the Board the following questions :—

- (1) Consumption of mineral fertilizers.
- (2) Nature of woods suitable for sulphite paper pulp.
- (3) Classification of soils and distribution with regard to geological formations.
- (4) The magnetic survey of the northern edge of the Deccan trap.
- (5) The discharge of the large rivers of India.

The Board resolved that the question of consumption of mineral fertilizers should be referred for report to the sub-committee on Soils and Manures ; and that the investigation regarding the nature of woods suitable for sulphite paper pulp should be referred to the sub-committee on Forest Products. With regard to the classification of soils, it was resolved that the Inspector-General of Agriculture should be asked to furnish the information required regarding the recognized classes of soils. The question of the magnetic survey of the Deccan trap was

noted by the Surveyor-General. With regard to the discharge of the large Indian rivers it was resolved that the Director, Geological Survey, should be asked to submit, through the sub-committee concerned, a more detailed memorandum, and that the Government of India should then be requested to consider the matter in the Public Works Department.

3rd Meeting held at Calcutta on the 11th December 1903.

A letter from the Government of India forwarding correspondence between the Secretary, British Cotton Growing Association, and the Secretary of State for India, on the subject of the survey of existing cottons of India and the improvement of Indian cotton was read, and referred for report to the sub-committee on Agricultural Products.

A letter was read from the Government of India forwarding papers on the subject of the deterioration of jute communicated by the Government of Bengal. The subject had already been referred for report to the sub-committee on Agricultural Products.

The report of the sub-committee appointed at the previous meeting to consider the suggestions of Professor Dunstan of the Imperial Institute was read, along with a letter from the Government of India, requesting the opinion of the Board with reference to the question of permitting direct correspondence between the Director of the Imperial Institute and the various Government Departments. The Board, agreeing in the findings of the special sub-committee, recommended that whenever the Director of the Imperial Institute had received sanction through the prescribed official channel to originate an investigation, and a particular department in India had been instructed to co-operate, he should be permitted to correspond direct with that department. The Board supported the principle of preserving duplicate samples at Calcutta, but considered that this necessity would be sufficiently met if the Director of the Imperial Institute agreed to transmit to the Reporter on Economic Products, Calcutta, a representative sample of every article examined by him.

A note on the discharge of large rivers by the Director of the Geological Survey was read. Mr. F. J. Spring, who had been invited to attend the meeting of the Board to assist with his expert opinion, explained that the points to be investigated were :—(1) the discharge

of, and (2) the quantity of silt in, the various Indian rivers, and made suggestions as to the manner in which the enquiry might be conducted. It was resolved to strongly recommend the proposed investigation to the favourable consideration of Government.

The Board considered the report submitted by the sub-committee on Agricultural Products on the questions raised at the previous meeting by the Director, Botanical Survey of India, regarding the sources of Indian fibres and the possibility of an industry in connection with the extraction of flax fibre. They accepted the recommendation of the sub-committee that the general question should be dealt with systematically by the Botanical, Economic and Agricultural Departments conjointly. As regards the extraction of fibre from the flax plant they resolved that the Inspector-General of Agriculture should be asked to give the results of his experimental enquiry, when finished, as to whether the plant could profitably be cultivated for fibre as well as for seed. They agreed with the opinion of the sub-committee that the enquiry regarding rubber should be conducted by the Forest Department, but recommended that any chemical investigation in connection with the subject should be entrusted to Professor Dunstan of the Imperial Institute.

The draft Annual Report of the Board as prepared by the Secretary was considered and passed.

The Board resolved that members should be requested, when submitting their Annual Departmental Reports, to append a list of such scientific papers by individuals as bear on the subject with which the department deals.

The question of testing building materials was brought forward by the Director of the Geological Survey, and he was requested to consult the Principal of the Civil Engineering College at Sibpur and to submit a memorandum showing the kind of sample and the character of the information desired by him.

4th Meeting held at Calcutta on the 24th of March 1904.

The Director of the Geological Survey presented a memorandum showing the kind of sample and the character of the information desired in connection with the testing of building materials; and it was resolved that the memorandum should be submitted to the Government of India

with a recommendation that the Department of Public Works should arrange for the collection of the samples, and should send them to the Engineering College at Sibpur, with the request that the Principal would transfer the fragments, which remained after testing, to the Director of the Geological Survey for microscopical examination.

The Board considered a note by the Surveyor-General on the proposed revision of the maps of the Raniganj and Jherria coal-fields, along with a note by the Director of the Geological Survey, and resolved to recommend to the Government of India that the revision be taken up and carried out at an early date.

It was resolved that an additional sub-committee should be formed to advise on veterinary subjects.

An India Office Despatch communicating the observations of the Royal Society's Advisory Committee on the Proceedings of the Board for 1902-03 was read. The Advisory Committee especially alluded in their letter to four questions:—(1) the preparation of a manual of cultivated plants, (2) the desirability of including the Godavari amongst the rivers to be studied as regards discharge of silt, (3) sewage disposal, (4) veterinary bacteriological investigations. With regard to (1) the Advisory Committee endorsed the Board's recommendation. With regard to (2) the Board had already recommended the inclusion of the Godavari amongst the rivers to be investigated. With regard to (3) the Board agreed with the Royal Society's Advisory Committee that the value of investigations regarding sewage disposal would be enhanced by a consultation between investigators in India and those in England. With regard to (4) the Board resolved to appoint a special sub-committee to deal with the subject generally.

The draft programmes of work of the various scientific departments for 1904-05 were considered and passed, with the exception of the programme of the Civil Veterinary Department, which was remitted to the Inspector-General for reconsideration with reference to the remarks made by the Royal Society's Advisory Committee.

5th Meeting held at Calcutta on the 3rd January 1905.

The Board nominated Captain A. T. Gage, I.M.S., to act as Secretary during Lieutenant-Colonel Prain's absence.

A letter from the Government of India, stating that, owing to lack of staff, it was not in a position to carry out the revision of the maps of the Raniganj and Jherria coal-fields, was read and recorded.

The report of the sub-committee on Agricultural Products on the deterioration of jute in Bengal was then read and the Board resolved to accept the report and forward it to the Government of India.

Intimation was received from the Chairman of that sub-committee that it was impossible to submit a report on Indian cotton until the details of the experimental cultivation undertaken by the Agricultural Department had been obtained.

A report by the sub-committee on Forest Products on the question of wood pulp and bamboo pulp for paper-making was then read. The Board requested the sub-committee to give further consideration to the question of the source of the sulphur required by the sulphite process, and to furnish information as to the localities of the principal sulphide ore deposits and of the principal woods of suitable kinds. The Director of the Geological Survey was added to the sub-committee for this special enquiry.

The report of the sub-committee on Veterinary subjects regarding Veterinary bacteriological investigations in India was approved and forwarded to the Government of India.

The draft Annual Report of the Board for 1903-04 was considered and approved.

The President was empowered to refer questions to sub-committees for report to the next meeting of the Board, and in cases of urgency to submit direct to Government the report of the sub-committee. Heads of Departments were requested to send in to the Secretary, at the time of writing their respective annual reports, a summary of the scientific work performed by their respective departments, for incorporation in the Board's Annual Report.

6th Meeting held at Calcutta on the 24th of March 1905.

A letter from the Chairman of the sub-committee on Agricultural Products was read, in which it was intimated that it was as yet premature to put forward a report on the varieties of cotton cultivated in India, until details of the experimental cotton cultures conducted by

the Agricultural Department had been received, and until the sub-committee had learned the latest views of Professor Gammie, who had made the subject a special study. The Board resolved that the Director of the Botanical Survey, the Reporter on Economic Products and Mr. Gammie should be asked to communicate with each other and arrange a scheme of co-operation.

A letter was read from the Chairman of the sub-committee on Soils and Manures, intimating that the information available on the subject of Mineral Fertilizers was not yet ready for the consideration of the Board.

A letter from the Chairman of the sub-committee on Forest Products was read, intimating that a note on the locality of the principal woods and bamboos likely to be suitable for the manufacture of wood pulp was being sent to the Director of the Geological Survey with the request that he would furnish a list of the localities of the principal sulphide ore deposits.

The draft programme of the Board for 1905-06 was considered and was recommended for acceptance to the Government of India.

7th Meeting held at Calcutta on the 11th December 1905.

The Board passed a resolution expressing profound regret at the death of Dr. W. T. Blanford, C.I.E., F.R.S., a member of the Royal Society's Advisory Committee and a retired officer of the Geological Survey of India, whose record of valuable scientific work in connection with Indian Geology, Geography and Zoology covers a period of 50 years.

The Board expressed agreement with the Advisory Committee of the Royal Society as to the great importance, from the economic as well as the scientific point of view, of completing as quickly as possible the general Geological Survey of India and Burma, and strongly recommended an increase in the superior staff of the Geological Department in order to provide a sufficient number of officers for satisfactory progress both in survey and in economic investigations. They also agreed with the Advisory Committee as to the desirability of an organised effort being made towards the Botanical exploration of the areas not yet

investigated, and as to the importance of providing separate floras of the various provinces of India. They recognized that the work could not be undertaken by the staff of Economic Botanists employed by the Local Governments, and recommended that the scientific staff of the Royal Botanic Garden, Sibpur, should be increased to at least four officers, who should devote their attention to the flora of the regions not yet properly surveyed, and compile floras for those portions of the area under the Superintendent of the Royal Botanic Garden for which arrangements have not yet been made. They also recommended that Central India and the Central Provinces should for the purposes of the Botanical Survey be added to that area, and that a fifth officer should be attached to the Botanical survey and placed under the orders of the Director, with a view to providing the latter with a staff sufficient to meet the needs of Madras as well as those of the areas already under his charge. They also suggested that endeavours should be made to find some retired officer willing to undertake the preparation of a Flora of the North-West Himalaya.

The Board recommended that the Physiological investigation into the nature and causes of Lathyrism should be continued, and that a special officer should be deputed for the purpose, subject to the control of the Sanitary Commissioner to the Government of India.

The report of the Sub-Committee on the utilization of Indian timbers for railway sleepers and the production of creosote from Indian coal was forwarded for the information of the Advisory Committee of the Royal Society, with the recommendation that the results of the experiments now being carried on should be awaited. The Board were informed that arrangements were well advanced for the erection of by-product recovery oven on the East Indian Railway collieries at Giridih and that steps were being taken for the erection of similar by-product coke-making plant in other coal-fields, and that when those operations were in working order there would probably be a supply of creosote available in Bengal.

With regard to the preparation of a new edition of Sir George Watt's Dictionary of the Economic Products of India, the Board recognised the desirability of a new and revised edition being published as soon as practicable, but considered that it was not desirable for the

work to be undertaken until the abridgement now under preparation had advanced towards completion.

The Board considered the draft Annual Report for 1904-05 and resolved (1) that the report of the work done in the Imperial Institute should be printed as an Appendix to the Report, (2) that the Annual Report should be confined to scientific work done in India or with special reference to India, (3) that the draft section of the report on chemistry should be revised so as to omit all references to work not done on Indian materials. They also desired that their acknowledgements should be conveyed to the contributors of the various sections of the Report.

The Board considered proposals for organising a system of recording the movements of Himalayan Glaciers, which had been put forward through Colonel Burrard, Superintendent of the Trigonometrical Survey, and recommended that the Director of the Geological Survey should be requested to draw up, in consultation with the Surveyor-General, instructions as to the nature of the observations necessary and the methods for recording them, to be communicated to travellers and selected residents in the neighbourhood of the Glaciers to be observed.

Reports on (1) the discharge of silt from Indian rivers, (2) experiments for the improvement of cotton, (3) experiments in growing flax, were forwarded to Government.

ECONOMIC AND AGRICULTURAL CHEMISTRY

BY

J. W. LEATHER, Ph.D., F.I.C., F.C.S.

AND

D. HOOPER, F.C.S., F.L.S.

In dealing with the numerous investigations in this subject it has been considered convenient to arrange the items in the manner adopted in the Report and Programme of the Reporter on Economic Products, and in accordance with the arrangement of the Economic Court of the Industrial Section, Indian Museum.

Gutta.—A specimen of Pontianac from the Patiala State, tested at the Imperial Institute, contained moisture 54.5, resin 36.6, caoutchouc 7.6 per cent. It resembled commercial Pontianac from Singapore in composition and properties.

Gums.—*Anogeissus pendula*. A. Goris and G. Lefevre (*Bull. des. Sc. Pharm.* vol. 6., p. 17) draw attention to the advantages this gum possesses over Acacia gum. It is free from oxydase. The presence of oxydase in gum arabic and not in tragacanth has enabled E. Payet (*Rep. Pharm.* 1904, vol. 16, p. 301) to publish a method of detecting commoner gum in tragacanth when in powder. Numerous samples of gum belonging to species of *Acacia* have been tested by Hooper (*Indian Forester*, Sept. 1904) in regard to their viscosity, tannin, ash and moisture contents. P. Lemeland has tested the gum of the Mango tree, *Mangifera indica*, (*Journ. de Pharm. et Chem.*, 1904, vol. 19, p. 584). More than one-third is soluble in water, the solution has a laevorotatory action on polarised light, contains oxydase, and yields arabinose, galactose and pentose on hydrolysis.

Among the resins Dunstan has examined Rock Dammar or resin of *Hopea odorata* from Burma, also Black Dammar the resin of *Canarium bengalense* from Assam. In the Indian Museum, D. Hooper has examined the white resin of *Dipterocarpus pilosus* from Assam, and

the green resin of *Calophyllum Inophyllum*. An investigation has commenced of the resinous substance known in Burma as Pwe-nyet, a product secreted by species of *Melipona* or Mosquito bee. The fragrant oleo-resin of *Altingia excelsa* has been described and its composition given in the Agricultural Ledger No. 9 of 1904. The adulteration of shellac, which is exported largely from this country, has been the subject of examination with a view to detect impurities. The most recent contribution of importance is a paper by A. C. Langmuir [*Journ. Soc. Chem. Industry*, (1905), vol. 24, p. 12], "on the determination of Rosin in Shellac".

Oils and oils-seeds.—The seeds of the castor-oil plant (*Ricinus communis*) have received great attention at the hands of investigators during the year. Lipase, the lipolytic ferment in castor seed is more active than in other oleaginous seeds. In the presence of an acid lipase is capable of decomposing oils into fatty acids and glycerin in an almost colourless form. Of fatty acid 50 per cent. is set free in 24 hours. Lipase is also capable of decomposing in a similar manner the oils of olive, sesamum and linseed. M. Nicloux (*Comp. rend.* 1904, vol. 138, p. 1175) asserts that the substance possessing these properties in castor seed is the cytoplasm. Whether the cytoplasm is endowed with specific properties or whether it secretes a soluble ferment is a matter for further investigation. In a subsequent paper (*Comp. rend.* vol. 138, p. 1352) M. Nicloux concluded that the hydrolytic properties of the seed are due to the cytoplasm and not to a soluble ferment. L. Maquenne and L. Philippe (*Comp. rend.* 1904, vol. 138, p. 506) describe the constitution of ricinine, $C_8H_8O_2N_2$, a constituent of castor-oil cake. E. Schulze and E. Winterstein (*Zeit. Physiol. Chem.* 1904, vol. 43, p. 211) find that this principle is present in young etiolated or even green plants, to 12- to 15- fold extent than in the seeds; so far tyrosine and leucine have not been found.

The discovery of the true source of the Chaulmoogra seeds of commerce from the tree called *Taraktogenos Kursii* has been followed by a chemical examination of the expressed oil from the authenticated seeds. The result shows that this oil agrees in its characters with the commercial oil which has been used in leprosy for many years in India, Europe and America. F. B. Power and F. H. Gornall, in a paper entitled

"The Constituents of Chaulmoogra seeds" (*Journ. Chem. Soc.* 1904, vol. 85, p. 838) describe the isolation of chaulmoogric acid, palmitic acid, glycerol and phytosterol. The seeds also contain a hydrolytic enzyme and an unstable cyanogen compound. In a subsequent paper (*Journ. Chem. Soc.* 1904, vol. 85, p. 851) the authors discuss "The constitution of Chaulmoogric acid." Of other fixed oils from plants occurring in India, G. Fendler (*Apoth. Zeit.* 1904, vol. 19, p. 721) has investigated safflower oil (*Carthamus tinctorius*), the oil of *Aleurites moluccana*, useful as a drying oil for varnishes, and that of *Calophyllum Inophyllum* (*Apoth. Zeit.* 1905, vol. 20, p. 6). W. Mooser (*Landw. Versuchs.-Stat.*, 1904, vol. 60, p. 321) has separated a new alkaloid from earth-nut meal (*Arachis hypogaea*) in addition to the bases choline and betaine isolated by Schulze. The new alkaloid termed arachine, possesses poisonous properties. A full account of the oil of *Schleichera trijuga*, known as Macassar oil, has been published as an Agricultural Ledger, No. 1 of 1905.

The oil has been determined by Dr. Leather in the principal oil-seeds of India, each oil-seed being represented by some dozens of samples. The list of seeds examined included *Sesamum indicum*, the *Brassicæ*, *Eruca sativa*, *Guizotia abyssinica*, *Linum usitatissimum*, *Carthamus tinctorius*, *Arachis hypogæa*, *Ricinus communis*, *Papaver somniferum*, *Gossypium*, *Bassia latifolia*. The extreme variation which occurs in each of the crops has thus been ascertained.

E. G. Hill (*Journ. As. Soc. Beng.*, Vol. 1, No. 3, 1905, p. 74) has described the composition of the oil of the Bir Bahoti or "Rain's Insect" (*Trombidium grandissimum*). The author concludes that the oil is principally composed of myristodiolin, and that there are also present small quantities of stearin, cholesterol, and colouring matter. There is possibly also present an alcohol of high molecular weight belonging to the fatty series of carbon compounds.

The following essential oils have been examined :—

Andropogon Schœnanthus.—The essential oil of Ginger grass. Geraniol has been found to be the chief alcohol present.

Erythroxylon monogynum.—The essential oil of the bastard sandal. contains a crystalline compound of an alcoholic character.

Santalum album.—Seidler (*Apoth. Zeit.* 1904, 19, p. 795) describes the physical properties of genuine East Indian sandal wood oil.

Cinnamon.—The value of various kinds of cinnamon barks in cinnamaldehyde has been determined by J. Harries (*Zeit. Nahr. Genussm.* 1904, vol. 7, p. 669). The following amounts of cinnamaldehyde were found :—

Ceylon cinnamon		1'74—2'19
Cassia cinnamon		2'08—3'81
Cassia buds		3'7—6'0
Cinnamon chips		1'23—1'42
C. Tamala		1'8
C. Kiamis, Nees		Nil.

Lemongrass oil.—Messrs. Schimmel & Co. of Leipzig have described a modified test for and nature of the adulterant in commercial oils, and have criticised the reliability of Bamber's test for the measure of impurity.

Dyes, Indigo.—As the result of researches conducted in Bihar, Bengal, at least two papers on the subject of the Chemistry of indigo have been contributed to the Chemical Society of London. C. Bergthell (*Journ. Chem. Soc.* of 1904, vol. 85, p. 870) discusses the "Fermentation of the Indigo Plant," and shows that the fermentation is due to a specific enzyme occurring in the plant cells. The optimum temperature for the action is 50° C., and the temperature at which the enzyme is destroyed is 71° C. The rate of action is decreased by the presence of both acids and alkalis. Various antiseptics all produced inhibition, formalin to the greatest, and boric acid to the least extent. Emulsin can produce the indigo fermentation, but not myrosin. No evidence of [the existence of an oxydase in the indigo plant was obtained.

An account of the research work in indigo carried out at Dalsingh Serai Research Station, from 1903 to March 1904, has been written by Messrs. W. P. Bloxam, H. M. Leake and R. S. Finlow, and published by the Government of Bengal. A paper embodying the chemical results of the work has been contributed by W. P. Bloxam (*Chem. Soc., Proc.*, vol. 20, p. 159) and entitled "Our present knowledge of the Chemistry of Indigo." The author, after showing that all the methods for the purification of indigo by the use of solvents being open to objection,

devised a test based on the estimation of nitrogen by Kjeldal's method. Pure indigotin should give a nitrogen value of 10.68 per cent., and any substance giving figures below this standard would necessarily be impure. The author has estimated the percentage of nitrogen in the best specimens procurable, and found that they contained only about 90 per cent. of indigotin. The pure substance may be prepared in a crystalline condition by sublimation under diminished pressure. It has also been found that the red substance occurring in the cake obtained from plant indigo, and known as indirubin or "indigo-red," is not, as stated, a derivative of indigo, as it contains no nitrogen.

In a paper (*Journ. Soc. Dyers & Colourists*, 1904, vol. 20, p. 35) on "The Manufacture of indigo from the Indigo plant," C. Rawson shows there is no loss of indigotin, real or apparent, during the drying of natural indigo.

Rawson in 1899 discovered that Java indigo contained a yellow colouring matter. This substance has been examined by A. G. Perkin (*Chem. Soc. Proc.*, vol. 20, p. 172) who finds it to be identical with Kampherol, a colouring matter which has been separated by Gordin from galangal root.

E. G. Hill, in a paper read before the Asiatic Society of Bengal, describes the flowers of the Narsinghar plant (*Nyctanthes Arbor-tristis*) in dyeing, and gives an account of the separation and properties of the yellow crystalline colouring matter. The colouring matters of the flowers of two more Indian plants have been determined by A. G. Perkin. The colouring principle of the flowers of *Thespesia Lampas* consists of quercetin. In the flowers of *Hibiscus Sabdariffa* gossypetin is present, the same substance that occurs in the flowers of *Gossypium herbaceum*.

Tanning materials.—The analyses of new materials and the preparation of tanning extracts have been conducted during the year. W. R. Dunstan has examined a fresh consignment of Divi-Divi pods from Santal Perganahs, Bengal, and found 45.4 per cent. of tannin, a higher result than in any previous sample from India. A new tanning material has been brought to light in Assam. This is the bark of *Artocarpus Lakoocha* which, analysed in the Indian Museum, was found

to contain 8.5 per cent. of tannin. A sample of the root of *Rumex hastatus* from Naini Tal afforded 11.6 per cent. of tannin, and a sample of the root of *Polygonum amplexicaule* gave 15.9 per cent.

Extracts of Mangrove barks continue to interest workers in the leather factories in Europe, and reports are being received on the barks and extracts supplied by various countries. J. Paessler, (*Collegium*, 1904, vol. 91, p. 15) experimenting with mangrove bark as a tanning material, found that leather was fully tanned in a fortnight, and the results were rather better than with oak bark.

J. Paessler (*Collegium*, vol. 89, p. 369) has studied the behaviour of extracts of myrabolans when kept under various conditions of strength and temperature.

A. G. Perkin (*Chem. Soc. Proc.*, 1904, vol. 20, p. 171) has continued his investigation of catechin, the colouring matter of Gambier, and has compared it with acacatechin obtained from the extract of the wood of *Acacia Catechu*.

Medicinal Products.—A short reference is made to the various examinations of the following products of a medicinal or toxic nature:—

Curcuma longa.—The composition of samples of turmeric from China, Pubna and Alleppi, has been published by A. E. Leach. (*Journ. Am. Chem. Soc.*, 1904, vol. 10, p. 1210.)

Cycas circinalis.—Van Dongen has isolated a toxic glucoside, pakoin, and crystals of phytosterin from the fruit (*Pharm. Zeit.*, vol. 48, p. 425)

Datura Stramonium seeds.—W. R. Dunstan found 0.26 per cent. of hyoscyamine in seeds from Busharh. Samples of seeds from Egypt and Europe are richer in this alkaloid.

Entada scandens.—L. Rosenthaler has examined the saponins in the seeds of this plant. (*Archiv der Pharm*, vol. 241, p. 614.)

Gymnema sylvestris.—The leaves have been submitted to a chemical analysis by F. B. Power and F. Gutia (*Pharm. Journ.*, 1904, vol. 73, p. 234.). The authors isolated from the alcoholic extract a colourless, crystalline, laevorotatory modification of quercitol, hentriacontam, formic and butyric acids and resins. The gymnemic acid found by Hooper in 1888 was re-examined.

Gymnostachyum febrifugum.—The root of this plant, growing on the Western Coast, has been examined by Hooper (*Journ. Pharm.*, vol. 73, p. 4). It contains a bitter resinoid principle, a cholesterol, with small quantities of tannin and sugar.

Hyoscyamus muticus from Sind. W. R. Dunstan finds in the stems 0.36 per cent. and the leaves 0.38 per cent. of hyoscyamine. This yield is lower than that recorded for the Egyptian plant.

Psidium Guyava.—The leaves of the Guava tree contain resin, fat, tannin and essential oil; the latter yields eugenol. A. Altan (*Bull. de Pharm. de Bruxelles*, vol. 48, p. 193.)

Rusot.—A medicinal preparation prepared from the root and stems of species of Barberry is made in Northern India. Samples have been found to yield from 4 to 8 per cent. of berberine. The drug has been described and examined by D. Hooper. (*Journ. As. Soc. Beng.*, vol. 73, pt. 2, p. 176.)

Punica Granatum.—E. Leger has devised a process for the estimation of alkaloids in pomegranate bark (*Journ. Pharm. Chem.*, 1904, vol. 19, p. 329).

Strychnos Nux-vomica.—H. W. and S. C. Gadd have studied the distribution of fat and strychnine in the seeds of nux vomica (*Journ. Pharm.*, vol. 73, p. 246). E. Leger has also described the alkaloidal assay of the seeds. (*Journ. de Pharm. et Chim.*, 1904, vol. 19, p. 479.)

During the year Dr. W. R. Boorsma of Buitenzorg, Java, has published No. 11 of *Pharmacologische Mitteilungen*, giving the results of the examination of plants of the natural orders Ternstroemiaceæ, Guttiferæ, Rutaceæ, Rosaceæ, Compositæ, Myrsinaceæ and Apocynaceæ. These results are interesting from a phyto-chemical point of view.

Foods.—The chemical composition of the fruits of *Ficus bengalensis*, *F. Cunia*, *F. glomerata*, *F. religiosa* and the seeds of *Shorea robusta*, all of which are consumed as human food, were analysed by Mr. Otto Reinherz. (*Agricultural Ledgers*, 1904, Nos. 4 and 5, p. 25—32 and pp. 33—36.)

The composition and feeding value and the digestibility of a number of famine foods was determined by Drs. Noël-Paton and Crawford Dunlop at Edinburgh. The list included the seed of *Panicum colonum*,

P. javanicu and four unidentified species of the same order, *Eleusine ægyptiaca*, *Indigofera glandulosa*, *Coix Lachryma-Jobi*, the fruits and roots of *Nymphæa Lotus* and of *Cyperus bulbosus*, and the pollen of *Dregea volubilis*. The toxic action of the seed of *Eleusine ægyptiaca* and *Nymphæa Lotus* restrict somewhat the ration of these. Of those examined the best were *P. colonum*, a specimen going by the name Batterioo or Golio, the flower of *Dregea volubilis*, *Coix Lachryma-Jobi*, and *Panicum javanicum*. The roots of *Scirpus grossus* and *Cyperus bulbosus* provide poor food. (*Agricultural Ledger* 1904, No. 6, pp. 37-59.)

The composition of twenty-eight "pot herbs" has been determined by D. Hooper, some of them also after cooking. Many of them are characterised by a high proportion of proteids. (*Agricultural Ledger* 1904, No. 6, pp. 61-72.)

In the Indian Museum the seeds of Tanyin (*Pithecolobium lobatum*) from Tenasserim were analysed among other food stuffs. The seeds were fairly nutritious and afforded when mixed with water a penetrating essential oil composed of a sulphur compound of allyl.

Cyanogenetic glucosides.—Mention was made in the last report (page 20) that Power and Gornall had detected a cyanogenetic glucoside in the seeds of *Gynocardia odorata*, obtained from India. It has been named gynocardin. Power and Lees have continued the investigation of the glucoside which, like other similar glucosides, is associated with an enzyme, and is hydrolysed by the latter. d-glucose and hydrogen cyanide were obtained as products of the hydrolysis together with a third substance not yet identified. Gynocardin is also hydrolysed by boiling dilute hydrochloric acid, and hot barium hydroxide reacts with it, ammonia and barium gynocardinate being formed. (*Trans. Chem. Soc.*, Vol. 87, p. 349-57.)

Coffee.—The valuation of raw coffee depends at present on a "liquor" test. Dr. Lehmann has determined the specific gravity of a series of samples with a view to comparing this with the market value of the berry. To a certain extent coincidence is noticeable, but divergencies also occur. (*Vide Annual Reports of the Agricultural Chemist, Department of Agriculture, Mysore*, 1904, p. 9, and 1905, p. 17.)

For an account of the numerous experiments in sugarcane cultivation in Java reference should be made to "Verslag over 1904 van het Proefstation voor Sukkerriet in West Java Kagok te Pakatongan."

Country Spirit.—A most important measure in connection with Indian excise was inaugurated last November. It was considered desirable to make a thorough enquiry into the properties of country spirit which, under the present system of manufacture, is alleged to be harmful. Major C. H. Bedford, D. Sc., I.M.S., has accordingly been placed on special duty under the Finance Department, Government of India, with head-quarters at Kasauli, Punjab, and with the help of two chemical assistants recruited in London. The investigation embraces the chemical composition of the liquor, physiological action of the by-products, and means for improving the manufacture of the various classes of spirituous liquors made in India; and also to devise excise tests by means of which their quality can be effectually controlled. A comparative study of the existing methods of spirit analysis, with special reference to the quantitative estimation of by-products, was first carried out, the samples being either those of ordinary manufacture or prepared in the laboratory and containing known proportions of by-products. Much work was done on the question of freeing spirits from certain of the more noxious constituents. The question of obscuration of alcoholic strength was thoroughly investigated, and a simple means devised of examining distillery spirit for obscuration. Other scientific enquiries on Excise questions of importance have also been investigated, such as the means of distinguishing licit from illicit spirits; the best means of denaturing "industrial spirits;" "shrinkage" wastage in blending; and "breaking down" of liquors.

H. H. Mann has contributed a paper to the Society of Public Analysts, London (*Analyst*, 1904, No. 29 p. 149) on "Potable spirits used by the native population of India." The percentage of fusel oil was extremely high in nearly all cases. Furfural was present in all the samples of spirit except one.

Mineral and inorganic.

Rain, Dew and Atmospheric Dust.—The amount of ammonia and nitrate in rain water at Dehra Dun and Cawnpore was determined

nder the supervision of Dr. Leather for a period of twelve months, and the quantity of such combined nitrogen amounted, respectively, to 3.6 and 3.2 lbs. per acre, quantities similar to those found in other countries. The amount of these constituents present in the dew at Cawnpore during last cold weather were similarly determined. The concentration of the ammonia and nitrate was found to be somewhat greater than in rain water, ranging up to one or two parts of nitrogen per 100,000; but the total quantity of dew is so small that the amount of this combined nitrogen per acre was only about one-tenth of a pound. Similarly collections of atmospheric dust were made at Cawnpore during the hot weather, but the quantity there is so small that it cannot have any appreciable effect on soils.

Drainage.—Records have been maintained at Cawnpore, by means of gauges precisely similar to those at Rothamsted, and up to the present the following are the principal results. It was estimated that of 43.3" of rain which fell during the monsoon period, July to September 1904, 5" was required to make up for the loss by evaporation during the dry period, 4" ran off the surface during a very heavy fall on September the 9th, 25.7" percolated and somewhat less than 9" evaporated during the monsoon. The records show further that the amount of percolation is proportionate to the rainfall, and that the quantity of water lost by evaporation from the soil is greater during the monsoon than during the dry weather period; both results coinciding with the deductions obtained from the Rothamsted records.

The nitrate in the drainage water was also recorded, and unexpectedly large amounts were present. It is too early to discuss the figures, and although the drainage of the current year substantiates last year's deductions, the rainfall has been so small that but little drainage has been received; another year must elapse before the several deductions, which appeared tenable from the records of 1904, can be fully verified. The gauges were free from vegetation, and hence the quantity of water percolating and its accompanying nitrate were larger than would have occurred had the ground been occupied by growing plants. They were conditions of maximum loss.

Sewage.—The investigation into the rate at which sewage is hydrolysed in the septic tank, to which reference was made in the last year's

report, was continued at Manjri in August 1904. The results coincided with those obtained during the preceding cold weather, and show that the size of the tank required depends on the strength of the sewage as well as its quantity.

Iron in Natural Waters.—The determination of small quantities of iron, such as are met with in natural waters, was the subject of a communication to the Society of Chemical Industry by Dr. Leather. Such quantities of iron are usually too small to admit of being weighed. It was found that they could be measured as ferri-ferrocyanide (Prussian blue) or ferric thiocyanate in Lovibond's tintometer. In this manner quantities as small as one-hundredth part of one milligram in 20 c. c. of water can be estimated with considerable precision. (*Fourn. Soc. Chem. Industry*, Vol. 24, pp. 385-7).

Dr. P. C. Roy, Presidency College, Calcutta, has contributed the following four papers to the Chemical Society, London.

Mercuric Nitrite and its Decomposition by Heat. (*Fourn. Chem. Soc.*, Vol. 85, pp. 523-527).

The Sulphate and the Phosphate of the Dimercurammonium series. (*Fourn. Chem. Soc.*, Vol. 87, p. 9).

Theory of the production of Mercurous Nitrite and of its conversion into various Mercury Nitrates. (*Fourn. Chem. Soc.*, Vol. 87, pp. 171-177).

The Nitrites of the Alkali metals and metals of the Alkaline Earths and their Decomposition by Heat. (*Fourn. Chem. Soc.*, Vol. 87, p. 177-184).

In the Indian Museum analyses were made of certain shell-limes in order to compare their composition with that of limestone, and to estimate their values for building and manurial purposes.

It is important to notice in conclusion that the year has been signalled by the completion of the Cordite Factory near Wellington, in the Nilgiri Hills, and the manufacture of an explosive material of satisfactory purity compared with the cordite manufactured in England.

ASTRONOMY.

BY

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Meteorological Reporter to the Government of India and Director-General of Indian Observatories.

Solar Physics.—Research in solar physics is carried on under the direct control of the Government of India at Kodaikānal, the Director being Mr. Michie Smith. The chief instruments there are :—

- (a) A spectroheliograph recently made by the Cambridge Scientific Instrument Company. In this apparatus the image of the sun—made by a 12" triple-achromatic lens of 20' focus fed by an 18" Foucault siderostat—and the camera are stationary, while the collimating and camera lenses, each of 5" aperture and 6' focal length, together with the prisms and slits, are moved on a rigid framework.

The spectroheliograph arrived and was erected in August last: it is carefully designed and well made, and the photographs obtained are extremely promising.

- (b) Two 6" refractors with one of which an Evershed spectro-scope has been used since November, 1904.

These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

- (c) A spectrograph consisting of an 11" polar siderostat with a 6" Grubb lens and a 4" grating. The details have been improved, but the apparatus has been out of use for a large part of the year owing to building operations. It will shortly be used for sun-spot spectra.

- (d) A photoheliograph by Dallmeyer. With this a photograph of the sun is made daily when possible.

2. The routine work now includes photographs of the sun in ordinary and in mono-chromatic light, visual examination of sun-spots and faculæ, observations of widened and displaced lines in sun-spot spectra, and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes the publication of bulletins

of the observatory has been decided upon. Of these one was printed during the year 1904-05, and two have appeared since then.

There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief apparatus is:—

(a) a Foucault 12" siderostat with an 8" image lens and a spectroscope with a $1\frac{1}{2}$ " Rowland grating. With these daily observations are made of the twelve most widened lines in sun-spot spectra in the region D—F: the results are forwarded to Sir Norman Lockyer;

(b) an equatorial refractor with a Cooke 6" triple photovisual lens. This is provided with two 45° objective prisms, but has been dismantled during a large part of the year in order that alterations and additions might be effected;

(c) an equatorial reflector with a 20" mirror by Common. This has also been dismantled for alterations.

At Dehra Dun, under the Survey of India, the photoheliograph has been in regular use, and photographs of the sun have been transmitted to Greenwich for measurement in the joint series with those of Greenwich and Mauritius.

METEOROLOGY.

BY

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Meteorological Reporter to the Government of India and Director-General of Indian Observatories.

Study of the monsoon region.—Investigation has been carried on of the marine data for the northern Indian Ocean as extracted from logs, and of the pressure and temperature conditions in the countries bordering that ocean. The preparation of the series of daily charts extending southward to latitude 12° S and based on copies of logs made at Calcutta and Bombay was discontinued from 31st December 1904 in view of the extension of the area over which data are collected, and data are now coming in from Washington and Mauritius, as well as from Calcutta and Bombay, from ships whose voyages extend over an area extending from longitude 20° E. to 125° E.

and from latitude 25° N. to 50° S.; arrangements have also been made for the supply of copies of logs from London and Hamburg. As the observations of wind appear to be more reliable than those of pressure, a beginning has been made with the study of the connection between their abnormalities and those of Indian weather.

Meteorological data for the chief stations in south and central Asia, east and south Africa, and Australia have been collected, and the departures from normal of their monthly means have been tabulated up to date: these departures have been entered on a series of small charts for convenience in discussion, and have also been subjected to analysis with the view of finding causal relationships with Indian rainfall. Some relationships appear to have been established while others are merely foreshadowed: chief among the former is the prejudicial influence of very heavy rain in April and May at Zanzibar or the Seychelles, whether preceded by heavy snowfall or not, upon the subsequent Indian monsoon rainfall, especially on the Bombay side: among the latter may be quoted the surprising tendency of deficiency of pressure at Mauritius during June, July, August or September to be followed by *excess* of rainfall in India, and *vice versa*.

Investigation of the upper air.—Kites.—Owing to delay in the arrival of materials it was not possible to start ascents until 27th August 1905, when Mr. J. H. Field went to Karachi with eight kites of the "box" pattern made at Simla and three Dines' meteorographs recording temperature, pressure and humidity. The winding gear was for hand power and contained several devices for avoiding the usual difficulties: both it and the kites proved successful and no accidents occurred. Eleven ascents in all were made and the greatest height reached was 4,700 feet with two kites in tandem and 10,300 feet of steel wire out.

The moisture-laden wind from the Arabian Sea was found to extend up to between 2,000 and 3,300 feet, with a humidity varying from 70 per cent. to saturation, and an approximately adiabatic temperature gradient. An additional ascent of 1,000 feet into the gentle current above this was only rendered possible by rapid hauling in of the wire, and a strong temperature inversion was found in this relatively dry stratum.

Balloons.—For ascertaining the nature of the upper air currents it has been decided to use free balloons and to make observations of the path with two theodolites at a distance of $2\frac{1}{4}$ miles apart : as there is no chance of retrieving the balloons no meteorographs are employed. Some difficulty was found in securing a material that was impervious to hydrogen and light enough to reach great heights without adopting a larger size of balloon than was consistent with economy ; and gutta percha tissue weighing 100 grains per square foot was finally adopted. In each of two ascents made in October a height of 25,000 feet was reached, and the velocity of the air at that height was on the 6th $30\frac{1}{4}$ miles an hour in the direction 13° north of east, and on the 18th 35 miles an hour in the direction 17° south of east.

Daily Weather Work.—A beginning has been made with the preparation of files of small sized charts of typical depressions and storms for use in connection with the daily forecasting, so that in cases of uncertainty it may be possible to refer at once to previous cases of similar conditions. For subsequent verification and criticism full sized copies of the daily weather maps are being made, indicating as far as possible the character of the actual rainfall as given by the returns from the 2,500 rain-recording stations : these will materially increase mechanical facility in handling the records of the past and deducing practical maxims for future guidance.

Special researches.—Apparatus for measuring the electrical condition of the air has been set up at the Calcutta Observatory, and observations now form a part of the routine work. Professor Cunningham has also made a special tour in the Bay of Bengal just before the advent of the monsoon in order to ascertain whether special electrical conditions prevail at that time.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary and various administrative pamphlets, the following memoirs have been published during the year 1904-05 in the series of Indian Meteorological Memoirs :—

- (1) Discussion of monthly mean surface and underground temperatures deduced from observations taken at Lahore, Jaipur, Dehra Dun, Allahabad and Calcutta during the

years 1880-1901, by R. Ll. Jones, M.A., F.R.A.S., Meteorological Reporter to the Government of Madras.

- (2) Normal monthly and annual means of temperature, pressure, wind, humidity, cloud, rainfall and number of rainy days of stations in India, etc., by Sir John Eliot, M.A., F.R.S., K.C.I.E., late Meteorological Reporter to the Government of India and Director-General of Indian Observatories.
- (3) A preliminary investigation of the more important features of the meteorology of Southern Asia, the Indian Ocean and neighbouring countries during the period 1892-1902, by Sir John Eliot, M.A., F.R.S., K.C.I.E.

The printing of the meteorological and climatological atlas of India, which has been prepared by Sir John Eliot and is being published by Messrs. Bartholomew of Edinburgh, is nearly complete and the appearance of the work may shortly be expected.

During the past five years pilot charts showing the normal pressure, winds and currents for the Indian Ocean north of latitude 12° S. have been published and issued month by month to subscribers: the pressure and winds were based on the data collected in this office from 1893 to 1900. It is believed that an atlas containing the twelve monthly charts will be more useful than separate sheets of paper, and arrangements have been made for its publication: the normals on which the atlas is based have been brought up to date and charts, giving additional information, are being inserted.

TERRESTRIAL MAGNETISM.

BY

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Meteorological Reporter of the Government to India and Director-General of Indian Observatories.

Magnetic Observatories.—*Colába (Bombay) and Alibág.*—An observatory had been erected at Alibág in order to receive the magnetic instruments whose transfer from Colába would shortly be rendered necessary by the institution at Bombay of electric tramways: happily

the new building for the self-registering instruments has proved extremely successful in the fundamental requirement of preserving constancy of temperature. A set of three Watson magnetographs was brought into use at Alibág in March 1904, and a comparison of the new and old sites, which is to last until 31st March 1906, was then begun: the magnet of the new horizontal force instrument showed at first some lack of constancy, but it has now settled down sufficiently and the records promise to be quite satisfactory. It appears from the traces made on quiet days that the diurnal oscillations are then precisely similar in amplitude and phase at the two places.

A special staff of two computers was appointed in December 1904 to assist in the tabulation and discussion of the magnetic records of 59 years at Colába, and this work is still in hand.

Dehra Dun, Kodaikánal, Barrackpore and Toungoo.—Of these observatories, which have been established as base stations in connection with the magnetic survey, the first two were started in 1902, the third in August 1903 and the last in December 1904: they are all equipped with Watson autographic instruments for declination and horizontal intensity. A magnetograph for recording vertical force was erected at Dehra Dun in August 1905, and experiments for the elimination of the temperature co-efficient are now in progress: similar instruments will shortly be installed at the other three observatories.

The magnetographs at Dehra Dun, Kodaikánal and Barrackpore have behaved well throughout, apart from several interruptions at Kodaikánal due chiefly to fungoid growths which have appeared there several times. At Toungoo, as at Alibág, the magnet of the horizontal force magnetograph was found to be losing moment, and it was necessary to visit the observatory and "age" the magnet.

Magnetic Survey.—The preliminary survey of India for which sanction has been given is planned to involve:—

- (a) Observations for declination, intensity and dip at about 1,100 stations, whose distance apart will be comparable with 35 or 40 miles, the "density" being one station to 1,300 square miles.
- (b) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.

- (c) Data from absolute and self-registering instruments at Colába and the four special base stations already mentioned.

A beginning was made with field work in November 1901 and the operations up to the end of the year 1902-03 have been described in previous reports : by that time 370 stations had been visited and 9 repeat stations established.

In the year 1903-04 observations were made by 5 detachments at 233 new stations, while 8 new repeat stations were instituted and comparative observations made at the 9 already in existence.

Some discrepancies with previous determinations were found when the moments of inertia of the field magnets were re-compared, and the original values were provisionally adhered to pending an investigation of the cause.

During the working season of the year 1904-05, four field detachments were employed and much marching had to be done. Observations were made at 206 new stations and 4 old repeat stations. Five new repeat stations were also started, but the season's work was considerably and unavoidably curtailed, and 13 repeat stations had to be omitted.

Much of the remaining work of the preliminary survey is in difficult country, and progress will be slower than it has been; but it is confidently expected that the work will be completed by four detachments in two more years.

The magnetometers used in the field have behaved uniformly well during the past year ; but some of the dip circles have given considerable trouble, in spite of having been put into thorough adjustment and working order at the beginning of the field season. In view of these difficulties and the approaching installation of vertical force magnetographs a small earth inductor, as made by Schulze of Potsdam, of which the average errors are much less than those of a dip circle, has been ordered for Dehra Dun and the purchase of three others is under consideration.

Major H. A. D. Fraser, R.E., who had been in charge of the magnetic party, was ordered home in March 1905, and his place has been taken by Captain R. H. Thomas, R.E. The former conveyed the two Indian

standard inertia bars to Kew, and it was found that both had lost weight: sanction has accordingly been asked for the purchase of a delicate balance in order that such changes may be detected and the need of a re-determination of the moment of inertia indicated.

The computation of the season's field work was begun in May and is now approaching completion: good progress has also been made with the tabulation and reduction of the results for 1904 of the base stations.

GEOLOGY.

BY

T. H. HOLLAND., F.G.S., F.R.S., A.R.C.S.

Director of the Geological Survey of India.

General Geology.—The work of extending the geological map over previously unsurveyed areas has been the main object of three parties—one in the Northern Shan States, another in Central India, and the third in the Central Provinces.

In addition to these surveys, exploratory work was conducted in the Persian Gulf and in the Andamans and Nicobar Islands.

The work in the Northern Shan States has been in progress for the past five years, operations being impeded seriously by the way in which the country is covered with thick jungle and a heavy crust of weathered products. Over considerable areas it has been impossible to map boundaries with any degree of certainty, but the collections of fossils that have been made show the existence of strata of Cambrian, Silurian, Devonian, Permo-Carboniferous, Jurassic and Cretaceous ages. The fossils are now being described by specialists in Europe, some of the results being already in the press for publication in the *Paleontologia Indica*.

The discovery of *Productus*-limestone fossils in the Northern Shan States adds another locality to those previously reported, thus assisting in mapping the boundary of the old Gondwana continent on which our most productive coal measures were formed. *Productus*-limestone fossils have long been known in the Salt Range, the Central Himalayas, and Kashmir; but during the past few years they have been discovered

also in the Southern and Northern Shan States, in north-east Assam, and this year in Arabia.

In addition to the stratigraphical work done in the Northern Shan States opportunity has occurred for the study of some interesting problems in physical geology. Two of these form the subjects of special papers published in the *Records* of the Geological Survey—the natural bridge of travertine, on which the railway viaduct at Gokteik is built, and the recent changes in the course of the Nam-tu river.

In Central India, the past season's work was mainly in Bhopal territory. The formations mapped consisted mainly of Vindhyan strata, Deccan Trap, and laterite patches. As all three formations are nearly horizontal, and separated from one another by denudation-intervals which produced irregular surfaces, the work of mapping has been slow and tedious in comparison with the few results obtained of general scientific interest.

In the Central Provinces the work of mapping was limited to the area covered by the eastern half of Atlas Sheet No. 72, the rock-formations studied being Archean granites and gneisses, interfolded bands of sub-metamorphics resembling the Dharwars, and outliers of Deccan Trap, with underlying Lameta beds.

During the course of survey work on the Manganese-ore deposits in the Central Provinces, opportunity occurred for a detailed petrological study of the associated gneisses and schists in the Nagpur and Chhindwara districts. The chief groups of rocks had been surveyed some years before, and the observations then made have now been supplemented by microscopic work for two papers published in the *Records* of the Geological Survey. The petrological results cover the Deccan Trap flows and the associated Lameta beds, with the underlying Archean formations, which include various forms of granites, granulites, gneisses, schists, calciphyres and cipolins, as well as the manganese-ores. Amongst the results obtained the most interesting are (1) the data which support the theory first advanced by Professor Judd with regard to the origin of similar calciphyres in the Ruby Mines district from pyroxene-gneisses and granulites; (2) the extensive silicification of the Lametas and the underlying Archean gneisses in the areas that were once covered by the Deccan lava-flows; (3) the mineralogical habits

of the calcites and dolomites; and (4) the great variety of new silicates in which manganese occurs as a prominent constituent, forming remarkably pleochroic forms of mica, pyroxene and amphibole.

The formations examined in the Persian Gulf and adjoining parts of Arabia and Persia include a small area of Archean schists in Omán, as well as beds in which siliceous limestones are prominent, including fossils ranging from Carboniferous to Triassic. From about Jurassic times onward a more complete geological history of the Gulf region is obtainable. At the close of Jurassic times, or early in the Cretaceous, there was a great outpouring of basic igneous rock, in the form of huge sills and flows. At the beginning of the Cretaceous great folding and crushing movements took place, which folded-in these sills and flows among the older limestones, and produced the mountain ranges of Omán. In the ocean bed whose southern limit was defined by these upheaved older rocks were deposited the upper Cretaceous beds of Hippuritic limestone which cover such large areas in Persia and overlie the igneous rocks of Omán. Following closely upon these and, perhaps, extending into the eocene period occurred a great series of volcanic flows accompanied by the formation of thick beds of salt and gypsum. This volcanic area extended approximately over the space now occupied by the eastern and larger basin of the Persian Gulf proper. It seems likely that shallow water conditions prevailed here, and some of the lavas and tuffs of the Ormuz series were probably subaqueous. At the same time, or a little later, some of the Hippuritic limestone must have been undergoing denudation.

Succeeding this period of volcanic activity, that is to say in middle eocene times, occurred a depression of most of southern Persia, within which the eocene rocks were deposited. This was accompanied by an upheaval of the volcanic area of the Ormuz rocks into dry land, which formed a barrier separating the eocene rocks of Persia from those of Bahreyn. It seems not unlikely that this land barrier continued through the upper eocene, oligocene, and miocene into the pliocene.

It is difficult to say what amount of unconformity there is between the latest of the Nummulitic limestones and the lowest beds of the Mekrán series, but in any case such movements as took place seem not to have tilted the Nummulitics appreciably. It is also certain that

the rocks of Mēkrān age must have been laid down over much wider areas than they occupy at present, as outlying patches are found even in northern Persia, and very little of the Nummulitic area may have been dry land in miocene times. The southern limits of the Mēkrān sea, on the other hand, seem never to have stretched much beyond the present Persian coast. Minor movements undoubtedly disturbed the sea floor and perhaps elevated the Mēkrān coast and eastern Persia, before the deposition of the Bakhtiāri grits in the pliocene. But it was subsequently to this that the tremendous earth movements occurred which folded and faulted Cretaceous and Tertiary rocks alike, and elevated the pliocene sea bottom to 9,000 feet above the present sea level, forming the present mountain system of Persia. The actual Persian Gulf seems to have been less disturbed, as shown by the almost horizontal strata of the Mēkrāns in Henjam and the gently rolling eocene rocks of Omān and Bahreyn. It is on the whole likely that denudation continued over this area, and the carving out of the topographical features to which the floor of the Persian Gulf and the Gulf of Omān owe their present contour was concluded. The limit of this land was doubtless determined by the steep submarine cliff which runs along the Mēkrān coast and then, cutting across the Gulf of Omān, runs parallel to the Arabian coast. Later, a widespread submergence took place, which buried fathoms deep the steep mountain valleys, river systems and sea cliffs that were being carved out for so many ages previously. To movements of this nature we owe the deeply-cut inlets of Massandim, and the islands dotting the Gulf, which are merely isolated peaks of the Ormuz volcanic series just rising above the surface of the water.

In still more recent times an elevatory movement must have been proceeding throughout the Persian Gulf. The flat ledges cut by the sea around Muscat and now raised above sea level, the recent littoral deposits of Omān and Persia as well as in the various islands, the sea terraces of Bahreyn, are all evidence of a widespread recent elevation of this area.

In the upper portion of the Gulf the deposits of the great rivers have contributed to this work of reclamation in an entirely different manner. The records of the past furnish us with abundant proofs of

how continuous and rapid has been the process by which the cities of antiquity have one by one retired inland from the littoral, and have been replaced by others on sites where once there existed flooded marshes or navigable water.

The principal result of interest obtained in the Andamans was the discovery of fossils in the Northern island in rocks whose age was previously unknown. The most important of these fossils are the foraminifera which indicate an eocene age. On Paget island the fossils included the characteristic *Nummulites budensis* of oligocene age.

Paleontology.—The paleontological work done on behalf of the Geological Department during the year includes descriptions of Himalayan Triassic and Jurassic fossils by Professors Uhlig and Diener of Vienna; Cambrian, Silurian and Mesozoic fossils from the Northern Shan States by Miss M. Healey of Oxford and Mr. Cowper Reed of Cambridge; and the *Nummulites* of the Sind Tertiary formations by Mr. E. Vredenburg. The results in all cases are in the press for publication as new parts of the *Paleontologia Indica*. Mr. R. B. Newton of the British Museum has also published an account in the *Geological Magazine* of some pliocene fossils obtained from a number of concretionary boulders collected on the Mekrán coast.

Physical Geology.—The discovery of pleistocene vertebrate fossils in the alluvium of the Upper Godávari valley, referred to in the last Annual Report, has led to a study of the distribution of these pleistocene gravels in the river-valleys of the Peninsula and consequently of the changes of level which they indicate. One of the most interesting of these results is the evidence of a warping of the Peninsular mass along an anticlinal axis running N.N.E.—S.S.W. through Buldána in Berar and near Sehore in Bhopál. The pleistocene deposits of the Upper Godávari, which flows eastwards, and the lower Tápti, which flows westwards, lie to the west of this axis, whilst those of the Purna, which joins the Tápti, and the extensive deposits in the Nerbada lie to the east of the hypothetical axis. Whilst there is no proof that lakes were formed, the alteration in the slopes of the valleys, due to this bending of the crust, changed the erosive tracts of the rivers into areas of temporary deposition with the resulting accumulations of alluvium that have since been eroded but not entirely removed.

Since the last report was issued the Government of India have sanctioned the organization of work for the determination of the silt carried down by the larger Indian rivers. A Geological Survey officer has commenced operations at two points on the Indus river for which careful gauge readings recorded for over 50 years give an accurate estimate of the water discharge, and it is proposed later to take up work on the Kistna, for which careful estimates have been made for the water discharge over the Bezváda anicut.

Seismology.—The destructive earthquake which devastated a large area in the Punjab Himalayas on the 4th April 1905 has been made the subject of special study by the Geological Survey. Beginning at an early hour of the morning, when many people were still asleep, the more violent phases of the shock dealt summary destruction to life and property in the neighbourhood of the Kángra valley and Dharmasála; accomplished very great damage and caused considerable loss of life in the hilly tracts of Mandi State and Kulu; did serious damage to Dehra Dun, Mussoorie, Chakráta and other towns in the vicinity; and slight damage to the large towns of Lahore, Amritsar, Jullundur, Saharanpur and others similarly placed with reference to the centre. Outside these points again, in ever widening closed curves, the effects of the earthquake were felt with continually diminishing intensity, until the limits of its appreciation by the unaided senses coincided roughly with part of an ellipse passing through the following localities—Quetta, Surat, Ellichpur, False Point and Lakhimpur. This curve, if continued, passes into the little-known and unreported-on regions of the higher Himalaya and Tibet; but it may be trusted to represent approximately the limit of sensible appreciability in that direction also, and to include a total area of about 1,625,000 square miles. Finally, outside these points (save for a few doubtful observations from isolated places), the record of the now greatly reduced vibrations is instrumental alone, but at the same time very complete. Not only did the seismological stations of India and the Far East—including those of Bombay, Kodaikánal, Calcutta, Batavia, New Zealand and Japan—automatically register the earthquake, but so also did those of Europe and America, the records being unmistakably those of a very powerful shock. The earthquake

must therefore be regarded as a notable one in the seismological history of the present and just concluded centuries, and, inasmuch as 20,000 human beings are estimated to have perished by it it must also be ranked as one of the most disastrous of modern times.

Owing to the interruption of communications, it was not until the 6th of April that the full significance and magnitude of the shock became generally known in India, and steps could be taken for the proper scientific investigation of it. By that date, however, telegraphic warnings were issued by the Director of the Geological Survey to all District Engineers, Meteorological Observers, Telegraph Masters, Railway officials and others through their respective Departments, to record in writing the exact time and other details of the shock. These were followed by letters sent to the principal newspapers inviting volunteers all over India to answer a formulated set of questions, and to help in other ways by furnishing exact data. Question-forms were also despatched to all the provinces, as well as to Political Officers and Residents of Native States. For the personal gathering of detailed observations of the effects of the earthquake in the more seriously disturbed area four officers of the Geological Survey were specially deputed within ten days of the catastrophe.

All reports gathered from places near the epicentre agree as to the suddenness of the shock, and the absence of a noticeable crescendo. The silent testimony of the long death-roll is sufficiently convincing of the rapid development of the shock, and the absence of any reasonably prolonged warnings conveyed by the preliminary tremors. That such preliminary tremors occurred is, however, clear from the accounts of survivors in the Kángra valley and neighbourhood, as well as at more distant points. In some cases in Dharmasála these preliminary warnings are stated to have enabled persons to leave their dwellings just in time. Although 135 perished in the big Gurkha barracks, such tremors are nevertheless implied by the fact that scarcely any of the victims were found killed in their beds. One account from McLeodganj bazar states that these first effects were of the "nature of tremulous vibrations and were likened to the rustling of leaves in the wind." In Dehra Dun, also, minor preliminary vibrations are recorded which enabled those who were awake to reach the door. In Mussoorie, according to an eye

witness, preliminary tremors lasted from 15 to 20 seconds; and the same were noticed in Landour by several people. In Lahore preliminary shocks with intervals appear to have lasted for about 11 seconds before the arrival of the main shock.

A common description of the main destructive oscillatory movement applicable to the Kángra valley and Dharmśála shows that it consisted of a violent horizontal shock from north to south, followed by an equally violent counter-shock from the opposite direction. A few observers noticed a third shock like a "downward" sinking. There is a preponderance of evidence in favour of the second shock being slightly the more violent, or at least the more destructive, of the two, inasmuch as it was during it that "everything collapsed."

The distribution of the isoseismal lines, which have been mapped on the evidence of an abundance of independent reports from evenly distributed localities within the affected area, show that there was a main focus aligned parallel to the folded Tertiary rocks with a steep pitch to the E. S. E. in the Kángra area, and a subsidiary focus parallel to the first under the Tertiary mass in the Dehra Dun area. The depth of the Kángra focus was from about 18 to about 30 miles, with a pitch to the E. S. E. of about 13° . In both areas the geological map shows a noteworthy inbaying of the Sub-Himálayan Tertiary belt, and as the folding and fold-faulting of this tract, which has gone on since early Tertiary times, tends to straighten out the mountain foot into an uniform curve—the southerly convex curve of the Himálayan arc of folds—areas like those of Kángra and Dehra Dun, which show marked irregularities, are in a condition of strain, and are thus favourable to the development of faults, with the earthquakes that often accompany such rock-fractures.

With regard to the surface effects of the earthquake the following points were noticed:—

- (1) All the surface valley deposits of alluvium, sand, gravel and boulders appear to have been proportionately more heterogeneously shaken than solid rock.
- (2) Of rock, the soft Tertiary sandstones have been thrown into more destructive vibrations than the older and more compacted strata.

- (3) Narrow ridges with free ends (spurs) have been very much more shaken than broad areas and the flat hollows between the spurs.
- (4) In the case of the more distant vibrations and tremors, the great alluvial tracts, the flat-lying Vindhya and the Deccan trap areas with cotton soil, have rendered such weak vibrations apparent, whilst the ancient and steeply dipping Aravallis have resisted the shocks in a very noticeable way. As a consequence there occurs an isolated area round about Udaipur, Dungarpur, Puraigarh, etc., from which no accounts of any shock have reached us. It is interesting to note that this area was similarly barren of results in the 1897 earthquake, although the shock was recorded both east and west of it.

From observations made with regard to the overturn of pillars near Kágra, the acceleration of the wave particle at that locality was near 13 feet per second, with an amplitude of about $9\frac{1}{2}$ inches. The time of occurrence of the main shock in the Kágra area was 6h. 9m. (Madras time). The larger waves reached the seismographs at Colába near Bombay and at Alipur near Calcutta in exactly the same time, namely, 480 seconds, and as both places are just 950 miles from the main epicentre, the rate of transmission in both directions was 1.98 miles per second. The record obtained at the Kodaikámal observatory in South India showed that the same waves took 768 seconds to travel 1,497 miles. Taken along the arc this indicates a speed of 1.95 miles per second. The instruments at Tokio and other places in Japan registered a time which indicated an arcual velocity of 2.05 miles (3.3 kilometres) per second.

Steps have been taken to obtain a record of the numerous after-shocks which were felt and still continue in the meizoseismal area.

Since the Kágra earthquake occurred arrangements have been sanctioned by Government for the installation of seismological instruments in the Himálayan region. The instruments previously maintained in India were three Milne seismographs at Alipur, Colába and Kodaikámal, besides simple seismoscopes in Assam and Kashmir. An Omori-Ewing instrument, kindly lent by Professor F. Omori, was

erected during June at Simla in the office of the Meteorological Reporter, for the registration of distant and small shocks, and the purchase of new instruments, for the registration at Simla of macroseismic as well as microseismic disturbances, has now been sanctioned by Government.

Economic Mineralogy.—There has been satisfactory progress made during the past year in mineral developments in India. The local value of the minerals raised, for which trustworthy returns are available, rose from £4,981,677 in 1903 to £5,338,096 in 1904, whilst a still greater increase was shown in the activity in prospecting, for which the licenses granted increased by over 50 per cent. Amongst the minerals which have created new interests are the gold-bearing reefs of the southern Bombay Presidency and the alluvial deposits of the Burma rivers, for which encouraging prospecting results have been obtained; the chromite deposits in Baluchistan, where actual mining operations have commenced, and the iron-ore deposits of Raipur and Mayurbhanj, for the development of which a project is now being developed with a view to the erection of large iron and steel works at Sini on the Bengal-Nagpur Railway.

The *Records* of the Geological Survey published early in the year included a Review of Mineral Production for the previous six years, being the first of a series of reviews which are to be issued in the future for quinquennial periods.

During the past year, the survey of the known manganese-ore deposits was completed, and an account of the results is now in course of preparation for publication as a special memoir. The survey shows the existence of ore in quantities sufficient to meet the large export trade in the richest varieties for many years to come, and of practically unlimited quantities of lower grade which, at present prices, would not pay for the high transport charges to Europe and America, but would be available for the requirements of steel manufacturers in India. In the course of the survey, valuable data were obtained with regard to the geological relationships of the ore-bodies, and a number of new varieties of minerals were discovered.

Several additions have been made to the instances of aluminous laterites (bauxites) previously reported in Central India, Central Provinces

and in the Dharwar district. An account of the occurrences that may be regarded as reasonable "prospecting propositions" was published in part 2 of the current volume (XXXII) of the *Records of the Geological Survey*, in which the economic possibilities and limitations of these bauxite deposits was briefly discussed for the assistance of those who wish to undertake the enterprise of their development. Several concessions have been already taken up in the Central Provinces under prospecting licenses with a view to testing the value of the deposits. Arrangements are also well advanced for the introduction of bye-product recovery ovens for coke-manufacture with a view to the production, in the first instance, of sulphate of ammonia and tar, which have hitherto been lost in the primitive methods followed of coking in open ovens. With the establishment of large iron and steel works, there will naturally be an increased demand for coke, and a consequent increase in the output of bye-products requiring sulphuric acid. Arrangements have consequently been made by the Geological Survey Department for a thorough examination by diamond-drilling of the copper-sulphide deposits, known to occur at intervals along a band stretching across the Singhbhum district near Sini, where it is proposed to erect coking plant in connection with the projected iron and steel works.

A survey has been made of two bands of Dharwar rocks in South India, in which gold prospecting and mining have recently been undertaken. One of these is the so-called Maski band in which the Hutti mines are now being worked with a rapidly increasing output of gold; the other is the Gadag band further west in the Gadag taluk of the Dharwar district, where attempts are being made to open up and develop the ancient native workings which have honey-combed the auriferous quartz reefs to depths of at least 300 feet. Attention was directed by the Geological Survey to the promising characters of these occurrences in 1874, and though so long left neglected, the reports then published were adopted as the guide of the pioneer prospectors in 1900, whose work resulted subsequently in the organization of systematic mining operations.

The report, recently made of this area, is now in the press for publication in the *Records of the Geological Survey*, and gives a detailed account of the country rocks and reefs, the remains of ancient

mining operations, the prospects in alluvial and reef-gold and the subsidiary conditions affecting their exploitation.

In the Gadag band, the white auriferous quartz-veins occur in soft argillities, thus differing from the occurrences in the Nizam's Dominions and the better-known case of Kolar in Mysore, where the gold is obtained from the blue quartz-veins lying in hornblende-schists. The occurrence is thus different from what might be expected from the Kolar analogy; but it adds weight to the conclusion that no general rules can ever be framed as a guide for the occurrences of gold in untested areas; each field must be studied for the discovery of its special peculiarities, and the determination of the existence of payable gold is always a matter of simple observation from practical tests, not of deduction from general principles.

In the course of surveying the previously known coal-fields of Namma and Lashio in the Northern Shan States, the Geological Survey party discovered two new fields, one near Mansang (lat. $22^{\circ} 26'$; long. $97^{\circ} 57'$), and the other near Manse-le ($22^{\circ} 40'$; $98^{\circ} 16'$). All four fields form isolated basins lying on the plateau limestone of probably Paleozoic age, and consist of beds of sand, shale and coal of probably pliocene age.

In the Lashio field, the so-called coal is lignitic in character with large quantities of moisture and sometimes with a considerable amount of ash, resulting in a fuel of low grade which can only be of local value on the railways after briquetting. The lignitic coal in the Namma field is slightly better in quality, but still unfit in its raw state for use in locomotives. The most important seam in the field lies east of Namma village, where, for a proved distance of 2,400 feet, it varies in thickness from 7 to 17 feet. In the Mansang field $4\frac{1}{2}$ feet was the greatest thickness observed in any seam, whilst in the Manse-le field the thickest seam was 4 feet in thickness. Full descriptions of these fields with a discussion of their possible economic value will be published in a forthcoming part of the *Records* of the Geological Survey.

GEODESY

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.

Superintendent of Trigonometrical Surveys.

The geodetic operations, which are now in progress in India, may be classified as follows :—

- (i) Principal Triangulation.
- (ii) Levelling Operations.
- (iii) Astronomical Operations.
- (iv) Pendulum Operations.
- (v) Tidal Operations.

Though these several operations can best be described separately, they are parts of one whole, and they mutually support and supplement one another.

Principal Triangulation.—In 1904 the officer in charge of the topographical survey of Baluchistan asked that a series of Principal Triangulation might be carried westwards from the Indus along the parallel of 29° . Surveys and reconnaissances based on detached triangulations had been previously made in different parts of Baluchistan, and an accurate trunk series was now required to tie them together. To comply with this request the triangulation party of the survey of India was transferred from Eastern Burma and the completion of the Principal Triangulation of Burma has been postponed for the present.

The parallel of 29° traverses a wider extent of land than any other parallel of latitude. If physical difficulties were the only obstacles to geodetic work, it would be possible now to measure on the earth an arc of parallel embracing 130° of longitude, and stretching from Sanghai to Morocco. Of this arc the Indian triangulation from Burma to Baluchistan has already measured 34° .

During the winter of 1904-05 work was started near Kalat, and a double chain of triangles was carried 150 miles to the westward. This chain will be extended during the next few months to the east and connected with the great series of the Indus.

The primary objects of a fundamental triangulation are to determine accurately the relative positions of the *extreme* points in a survey, and to prevent any *accumulations* of error in the area under survey. In Baluchistan therefore the new triangles are being made as large and as few as possible. Two advantages ensue from this policy: (i) the positions of points can be fixed with the greatest accuracy, for every intermediate station in a chain is a source of additional error: (ii) the Principal Triangulation becomes cheaper and advances more quickly than secondary series of small triangles.

It is beginning, however, to be recognised that heights when determined over long distances are less reliable, being more adversely affected by the refraction of the atmosphere, than those obtained from short. But this fact is not a sufficient reason for replacing large by small triangles: the gain resulting from a reduction in size is not worth the sacrifice. The problem of refraction is a difficult one, and it may even be found necessary for its solution to have different programmes for horizontal and vertical observations. When the relative *horizontal* positions of two distant points are being determined, a loss of accuracy is introduced with every intermediate station: when the relative *heights* of the same two points are being measured, a similar loss of accuracy ensues, but in the latter case it may be more than compensated by the reduced effects of refraction, whereas in the former there is no compensation.

On April 4th, 1905, the Punjab Himalayas were severely shaken by an earthquake. A chain of trigonometrical stations, one of the permanent and fundamental chains of the survey, rests on the outer ranges of hills and the possibility that some of the markstones have been displaced from their original geographical positions has to be considered.

To those who are interested in the preservation of these marks for the use of the future the frequent recurrence of earthquakes in Northern India must necessarily cause uneasiness, but investigation shows that there are no real grounds for despair. Before we can accept the retrograde view that accurate triangulation is useless, we must have definite evidence of the actual effects of earthquakes: at present our ideas of the movements caused by earthquakes are based on no complete proof.

The stations on the hills round Dehra Dun have perhaps a special geodetic value in that they form the northern terminus of the arc of meridian, which Colonel Everest measured from Cape Comorin to the Himalayas. Two years ago Everest's arc was extended northwards into the mountains over a distance of 35 miles, and that it may eventually connect with a Russian arc in Siberia and reach the shores of the Arctic Ocean is a reasonable expectation.

It was therefore important that we should determine whether the terminal stations as fixed by Everest had suffered horizontal displacement from the earthquake, and as this could be done near Dehra Dun without expense, several horizontal angles, which had been measured before, were re-observed last summer. Owing partly to the heat and the haze the revisionary observations were not of the highest order of accuracy; and we are consequently unable to tell whether horizontal movements of six inches or less have taken place or not. A comparison of the results however shows (firstly) that no relative displacement of 8 inches has probably occurred near Dehra Dun, and (secondly) that no relative displacement of 12 inches can have occurred.

Our revisionary work was necessarily local, and we had to be content with determining the extent of relative displacement within the locality tested. It would not have been possible without great expense to discover whether there had been any general movement of the Himalayas.

There were originally erected in India 3,706 trigonometrical stations of the Principal Triangulation;* in 1904 there were 3515 surviving. In spite of measures taken to ensure preservation the average rate of decrease has been of late about four stations per annum. The rivers of northern India, by their constant changes of course, have been very destructive; encroachments of the sea has washed stations away; the expansion of railways, canals and towns has necessitated the removal of others; and movements of sand in the desert have caused a few to be buried.

It is not possible to state the number of stations which have been displaced by earthquakes from their original positions; but seeing that

* On an average one station in every 450 square miles.

severe earthquakes have only occurred of late years in certain Sub-Himalayan regions, and having regard to the recent reassuring observations round Dehra Dun, I do not think it probable that the number which have suffered greater disturbances than 8 inches can exceed 40 : and an estimate of 40 errs on the side of pessimism.

After the great earthquake of 1897 we discovered horizontal displacements in Assam of 8 feet and more.* Mr. Oldham was of opinion that these were merely relative displacements in the small area tested, and that the absolute displacement of the whole area would have been found to be considerable if we had commenced our tests outside the disturbed region and worked inwards to the epicentre. But triangulation is a slow and costly operation, and it is not practicable to revise great lengths of it after every earthquake. The small local revisions carried out last summer to test the effects of the earthquake of 1905 were rendered possible by the fact that Dehra Dun is the head-quarters of the trigonometrical survey, and observations can be taken in its vicinity without expense or difficulty. The damage however done at Dehra Dun by the earthquake was small compared to that at Dharmsala, and our proof that the stations round Dehra Dun have not been relatively displaced by 8 inches is no proof that those near Dharmsala have remained equally undisturbed. If moreover we apply Mr. Oldham's argument to the case of Dehra Dun, we shall have to consider that the whole region may possibly have moved, although the relative positions of local marks have remained unaltered.

From a topographical point of view a displacement of 8 inches may be disregarded, but one of 10 feet is liable to cause inconvenience and error. If we suppose, for instance, that of the two trigonometrical stations of Hathidar and Lipiana, which are situated in Kangra 16 miles apart, one has been displaced *towards* the other by 10 feet, then the line joining the two would no longer form a suitable base either for the observation of distant snowpeaks, or for a series of minor triangulation for Tibet, although the disturbance might not embarrass plane-tables surveying the immediate locality. If the displacement

* The revisions in Assam were made with a small instrument and the displacements were measured only to the nearest two feet : *vide* Report on the Trigonometrical Results of the Earthquake in Assam, 1898, paragraph 7.

had occurred in a direction *perpendicular* to the line joining the two stations, the accepted direction of this line would be in error by 25 seconds: and this is an error that would soon begin to inconvenience triangulators.

The Shillong Earthquake of 1897 rendered the positions of perhaps 15 stations uncertain, and the Dharmasala Earthquake of 1905 has possibly affected the same number. When in the future these stations come to be utilised, it will be necessary for observers to take the precaution of measuring the angles of two or three of the original triangles by way of a preliminary test.

We have long since had to introduce such a precaution into levelling operations: the heights of bench-marks when erected on alluvium are liable to vary with age, and when a new line of levels is being started from an old bench-mark it is not safe to accept its original value of height: it is always necessary to relevel to two or three of the old bench-marks in order to test for subsidence. Such a precaution has never hitherto been considered necessary in triangulation, because, although markstones may move vertically in the course of time, as a rule they maintain their horizontal positions. But there have been two severe earthquakes within eight years, and it is necessary now to recognise that in certain regions the positions of points will have to be accepted with greater caution in the future than in the past.

The displacement of the stations of the Principal Triangulation is but one aspect of the general problem of change which a survey has to face. The forms and positions of topographical features are always undergoing change. In certain cases the changes are so rapid that it is hardly possible to make a consistent survey at all: the Indus for instance is constantly eroding its banks, washing away survey and boundary marks, and altering its course perhaps by a mile or more. If the whole river were to be surveyed in one month, the map could be rightly headed "The course of the river Indus in January 1905," but to survey different portions at different times, as in practice we have to do, is to give a course to the river which it never actually pursued.

During the progress of the present survey of Sind many recently surveyed sheets have been rendered obsolete, almost before they have been published, by the opening of a new system of canals. And these

changes are going on everywhere from those that are so local and marked as to be perceptible to the most casual observer, to those that are so widespread and gradual as to require lengthy revisions of triangulation to reveal them.

The vertical angles of Everest's triangulation and his resulting values of height were very inaccurate. The *horizontal* angle between two distant stations can be accurately determined, because rays of light in passing through the atmosphere are not refracted laterally. But the measurement of the *vertical* angle between any point and the observer's horizon is always affected by atmospheric refraction.

Refraction varies with temperature and is least during the hottest part of the afternoon. When however refraction is least, the object to be observed is invariably blurred and unsteady: and when refraction is greatest and most harmful, the object becomes clear and definite.

In the days of Everest it was thought advisable to secure good clear signals for observation, and work during the afternoon was avoided because the signals were jumping and difficult to intersect. But heights by vertical angles were continually being found discordant, and discrepancies of 50 feet between two determinations of one height were common.

In 1850 Sir Andrew Waugh pointed out that if observers would do their best to intersect unsteady signals and would observe in the afternoons, their values of height would be found of greater accordance and accuracy than if they waited for the signals to be *sharp* and still. This reform of procedure proved most beneficial; errors of intersection due to the unsteadiness of the object *have* been found to be trivial compared to the errors caused by atmospheric refraction, and vertical angles are now always observed between 2 and 4 P.M.

But a large number of the Principal Trigonometrical heights of India were determined before 1850: they have never been revised and their inaccuracy is a continual source of trouble to topographers.

It must not be assumed that values of height observed by Waugh's method are wholly satisfactory: they are still affected somewhat by refraction, and can seldom be trusted within 6 or 7 feet.

Errors such as 6 or 7 feet are met with in India where stations have been mutually observed from one another, but in the case of

inaccessible snow-peaks the uncertainty is far greater: the air in these cases is rarefied and cold, the rays are of extreme length and traversing a white surface, and no reciprocal observation from the peak to the station in the plains is possible.

It is felt that endeavours should be made to reduce still further the evil effects of refraction, and an experimental investigation has been commenced at Dehra Dun. It is too early to say whether it will bear fruit, but the results of the Trigonometrical Survey are being compiled and classified in the hope that some useful information may be deduced.

In a country such as England, where the standard maps are on the $\frac{6 \text{ inches}}{1 \text{ mile}}$ and $\frac{25 \text{ inches}}{1 \text{ mile}}$ scales, it is economical to carry spirit-levelling everywhere; but in India, where the standard map is on the small scale of $\frac{1 \text{ inch}}{1 \text{ mile}}$, spirit-levelling is more suited at present to furnish a mathematical framework than to fill in interior details of relief. If then we could reduce the probable error of trigonometrical heights, a great service would be rendered to topography.

It will be understood from what has been said above that vertical displacements caused by an earthquake cannot be measured with any accuracy, if the original values of height have been determined by vertical angles. It happens however that the height of Mussoorie has been determined by spirit-levelling, and the effect of the recent earthquake can thus be ascertained within certain limits and will be discussed below.

Levelling Operations.—India has been intersected by lines of spirit-levelling and numerous circuits have been formed, but the closing errors of the circuits have never yet been distributed. It is inconvenient to continue with the heights of our bench-marks in preliminary values, and endeavours have been made of recent years to accelerate the mathematical adjustment of the net. But before this is undertaken, a certain amount of additional fieldwork has still to be carried out; some of the levelling circuits are at present very large; some areas, of which the Punjab is one, have not as yet been enclosed; some tidal stations such as Chittagong and Porbandar, have not been connected with the net; and some of the old lines may have to be revised.

It was at one time proposed to postpone the simultaneous reduction of the level net until the Indian and Burman systems of levelling had been connected. Theoretically this course would have been correct, but we are anxious to obtain final values for our spirit-levelled heights at an early date; and in 1903 it was decided to adjust the Indian levelling first and to build that of Burma upon it.

In Europe and America great revisions of levelling are carried out in order to reduce the closing errors of circuits, but in India the necessity of extending our levelling over new ground has always been so great that there have been no opportunities for revision. The amount of revision that will now be necessary, before the adjustment is carried out, depends upon the results furnished in the early stages of revision and cannot be exactly stated beforehand. There has been only one serious error brought to light in India, and that is the discrepancy of 3 feet on the line between Bombay and Madras. If we are to accept the results of the levelling over that line the mean sea level at Madras must be 3 feet higher than that at Bombay: there is no reason to suppose that the sea level at either place is permanently affected by currents or winds, and we have no alternative but to assume that the discrepancy of 3 feet is an accumulation of error in the levelling observations. The length of the line is 796 miles, and the error accumulated is at the rate of 0.004 foot per mile. The Ordnance Survey allows an error of 0.01 foot per mile over short secondary lines, but as the accumulation of error over long primary lines should increase with the square root of the distance, the discrepancy at Madras is too large to be passed. It is now believed that the error must have been generated in the 200 miles between Gooty and Gulburga, and it is proposed to revise this section at an early date: if the error can be located, no further revision between Bombay and Madras will be needed.

During the winter of 1904-05 the levelling detachment of the Survey was employed in carrying a line of levels along the east bank of the Indus in Sind. The detachment returned to Dehra Dun in May and, under ordinary circumstances, would have been employed at once in reducing their fieldwork and compiling their results.

But on April 4th, 1905, Dehra Dun and Mussooree had been shaken

by the earthquake, and the levelling detachment was accordingly directed to relevel the line connecting the two places. This short line had been levelled over during the previous year, in order to furnish us with a means of testing the influence of atmospheric refraction on vertical angles observed between the hills and the plains.

In May 1904 the trigonometrical station at Mussooree was found by levelling to be 4,706 feet 10 inches higher than the station near the Survey Office at Dehra Dun. In May 1905 the difference of height was found to be 4706 feet $4\frac{1}{2}$ inches. It would therefore appear that the Mussooree range has subsided $5\frac{1}{2}$ inches with regard to Dehra Dun.

When the results were first tabulated, it was perceived that the amount of subsidence increased gradually as the levellers ascended the range. This gave rise to a suspicion that the lengths of the levelling staves may have been in error.

During the first 6 miles the ascent is 694 feet or 116 feet per mile, and in the last 12 miles it is 4,013 feet, or 334 feet per mile. A levelling staff being 10 feet long, and the difference of height being 4,707 feet, there were contained in the total rise 471 lengths of staff. If then the 10 foot staves had been 0.001 foot too long, our unit of measurement would have been slightly in error, our measured heights would all have been given too small and the deficiency accumulated at Mussooree would have been 0.471 of a foot, or about $5\frac{1}{2}$ inches.

Four different staves are however in daily use, and these are periodically compared in the field against a 10 foot steel standard and corrections for each deduced. An examination of the results of the comparisons showed that the apparent subsidence of Mussooree could not be attributed to errors in the adopted lengths of the four staves.

The steel standard, against which they were compared, was then suspected, and this was subjected to rigorous tests under comparing microscopes at Dehra Dun. Its length, as now determined, accorded with the value previously obtained, and it became clear that the observed change in the height of Mussooree above Dehra Dun between 1904 and 1905 could not be attributed to any error in the adopted length of the standard of reference.

During the process of levelling the level is always erected midway between two staves, and at each station the observer by reading the staves through the telescope deduces the *difference* in height between the two points on which the staves are standing. Under ordinary circumstances there is no reason to fear accumulation of error. But when the line followed is constantly rising, as between Dehra Dun and Mussooree, the rays of light from the telescope to the higher staff pass always nearer the ground and are more likely to be disturbed by radiation than the rays to the lower staff: this fact introduces an uncertainty, which continues to exist whether we work up or down the hill, and which we endeavour to minimise by stopping work during the heat of the day. We are not, it is true, discussing now the absolute value of the height of Mussooree. The levelling observations of both 1904 and 1905 were taken in the month of May under similar atmospheric conditions, and we are only attempting to account for the *difference* of $5\frac{1}{2}$ inches which appeared between the value obtained in May 1904 and that of May 1905. Nevertheless it has to be recognised that an uncertainty does exist: it was the examination of this question that really revealed how little was known of the degree of accuracy of a line of levels on a steep slope. It is at times extremely difficult to obtain a definite numerical idea of the probable and possible errors which are accumulating in a lengthy survey operation, but a knowledge of these errors is essential before we can discuss the meaning of an actual discrepancy observed. In the levelling operations carried over the plains and peninsula of India no error approaching $5\frac{1}{2}$ inches in 18 miles has been met with,* and if by further levelling in the coming cold months we reproduce the same value of height for Mussooree as was last obtained during the heat of May, we shall then perhaps be justified in assuming that no exceptional error has been accumulated during the work, and that the difference observed of $5\frac{1}{2}$ inches is due to a real change.

Astronomical Operations.—The Principal Triangulation becomes of service to topography from the date of observation, but it is not

* The great error between Bombay and Madras may have been partly generated in the steep ascent of the Ghauts on the Bombay-Poona section, but the weight of the evidence is against this view.

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of geodetic use, until astronomical observations have been taken at certain of its stations.

The astronomical tests are required—

- (1stly) to determine whether errors imperceptible in themselves are not tending to accumulate in long lengths of triangulation ;
- (2ndly) to show whether the triangulation is being projected upon a spheroid that conforms closely to the actual figure of the Earth.
- (3rdly) to indicate the direction of gravity at the station of observation, and the inclination to the mathematical horizon assumed under the influence of gravity by the levels of the astronomical instrument.

Astronomical observations were originally introduced to provide a foundation of fixed points for topography, but they were found insufficiently accurate for the purpose, owing to the fact that the force of gravity does not always act in the direction of the normal to the Earth's mathematical surface. At first sight, then, it seems peculiar that the astronomical method, which had to be discarded in favour of the triangulation, should now be utilised to check the accuracy of the latter. The explanation of the apparent anomaly is that the error of astronomical work remains constant, whilst the error of triangulation accumulates with the distance travelled, and that although the true distance and direction of Lucknow from Agra may be more accurately determined by triangulation, the distance and direction of Mandalay from Karachi can be best deduced from star observations.

Of recent years astronomical observations have been systematically taken with the object of determining the effects of the Himalaya mountains on the plumb-line. These observations brought to light the extraordinary facts that a flat, narrow zone of the Earth's crust, surrounding the Himalayas on the side of India, is extremely deficient in density, and that, to the immediate south, a second and parallel zone exists throughout which the density of the Earth's crust is abnormally great. From astronomical determinations alone we were not able to measure the exact deficiency or excess of matter underlying any parti-

cular station ; but this will now be rendered possible by the pendulum observations.

In 1904 Captain Cowie, R.E., accompanied the Tibet Mission to Lhasa, and on his return was occupied for some weeks in compiling maps of Tibet. His topographical duties lasting till December, he was not able in 1904-05 to undertake a full astronomical programme. He was therefore directed to observe four latitudes in South Burma, which were required by the Director of the International Geodetic Association, and one azimuth at Chittagong, which was badly wanted for an investigation of the errors of triangulation.

A new determination of the figure of the Earth is now being made at Potsdam, and two of the Indian measurements are being utilised, *vis.*, the arc of meridian from Cape Comorin to Dehra Dun and the arc of parallel from Karachi to Moulmein. The Indian arc of parallel starts from a point near the telegraph office at Karachi and ends at a point near the old Artillery Mess at Moulmein : the distance in feet has been measured by triangulation and the difference of longitude has been determined astronomically.

The triangulation that has been carried west of Karachi into Baluchistan, and that which has been taken east of Moulmein, increase the measured length of the Indian arc, but they will not be of use in determinations of the Earth's dimensions and shape, until they have been supplemented by astronomical observations.

The arc between Karachi and Moulmein is now complete, Captain Cowie's observations in Burma having supplied the data that were wanting.

The latitude of Moulmein has been given as follows:—

As calculated through the triangulation.	} 16° 29' 54.62"
As observed from the stars by Captain Cowie.	} 16° 30' 2.97"
The astronomical value exceeds the calculated value by	} 8.35"

This discrepancy of $8.35''$ is due to three different causes: firstly, the deflection of gravity at Moulmein has rendered the astronomical value too large; secondly, the triangulation in its journey across India and Burma has slowly deviated southwards from the correct course, and has consequently placed Moulmein on the earth too far south in latitude by a few seconds; thirdly, the triangulation has been projected on too small a spheroid, and has been consequently extended over too large a proportion of the Earth's circumference.

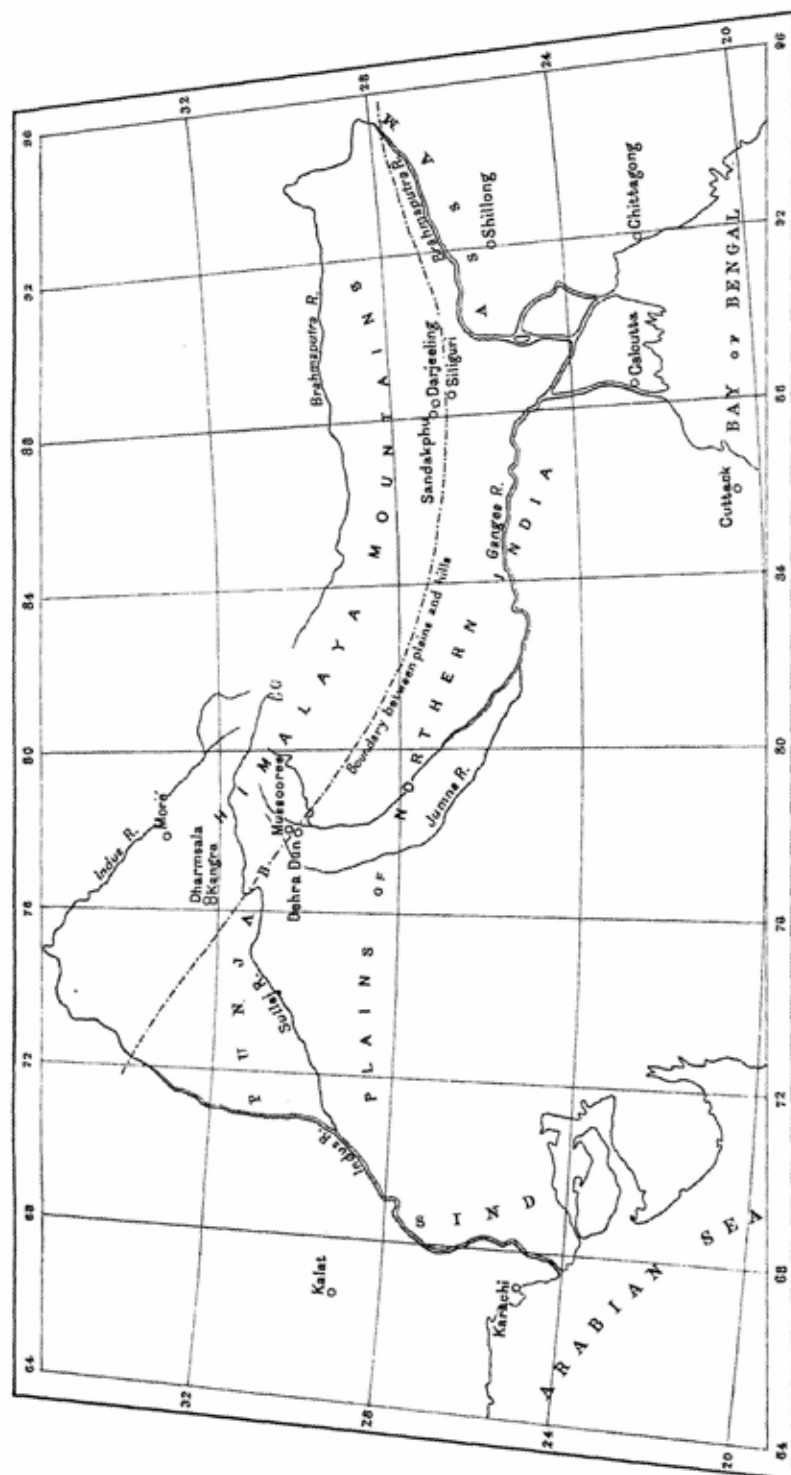
It would have been better in many ways if we could have ended the arc of parallel in Upper Burma near the latitude of Karachi. Moulmein is so far south of Karachi that the arc becomes technically an oblique arc: when longitude observations have been taken in Upper Burma this defect will disappear.

The azimuth which Captain Cowie observed near Chittagong formed part of a scheme for determining the error in direction which the triangulation has gradually accumulated throughout its length. An investigation of this error has been carried out at Dehra Dun during the summer of 1905, and the result will be shortly published in a volume on Geodesy.

The error of direction that has been generated in the Indian triangulation is always of the same kind: it is too small to be perceptible in short distances, but its accumulation seems to be steady and persistent. As we move from Karachi to Moulmein the triangulation tends to deviate to the south, and as we move from Peshawar to Cape Comorin it tends to deviate to the west: the deviation is always clockwise. When an error is very persistent, it is natural to suspect the existence of a definite cause, and we have endeavoured to examine, but so far without success, whether the deformations of the level surface in India would tend to throw the triangulation out of its course. All that can be said is that in this country the level surface does not conform to the spheroid, and that when we project the triangulation on the spheroid we meet with a persistent deviation; but whether this deviation is caused by the departures of the actual geoid from the assumed spheroid or whether by the accumulation of imperceptible errors of observation, we are not able to state.

CHART

illustrating the report on
PENDULUM OPERATIONS.



Pendulum Operations.—The new pendulum apparatus arrived in India in 1903. It had been previously standardised at Greenwich and Kew, and Major Lenox-Conyngham's first task in India was to make a Base-Station of Dehra Dun by taking an exhaustive series of observations there. The result he finally obtained was as follows:—

	dynes
The force of gravity as observed at Dehra Dun	979'063
The normal force of gravity of any place situated in the latitude and at the elevation of Dehra Dun, accord- ing to Helmert's formula of 1884	979'186
Deficiency of the actual force below the normal	0'123

Between thirty and forty years ago Captain Basevi determined the force of gravity at a few stations in India of which Dehra Dun was one. When Major Lenox-Conyngham had completed his observations of 1903, he found that his result was considerably larger than Basevi's, and he proceeded in consequence to visit three other of Basevi's stations. At each of these he met with a similar disagreement, his value always exceeding Basevi's. Professor Helmert, Director of the International Geodetic Association, had predicted that these differences would appear, and had given his reasons for believing that all Basevi's values were too small. The deficiencies in the latter are due to the fact that in Basevi's days there were no means of measuring or allowing for the swing of the pendulum's stand. When a pendulum hanging from a stand is set in motion, the friction at the points of suspension causes the stand to swing also. In former years observers endeavoured to remedy this evil by making their stands heavy and rigid, but it is now known that such expedients are ineffectual: masonry pillars and iron frames are equally liable to be set swinging, if an oscillating pendulum is in contact with them. By a recent invention it is possible to measure the oscillations of the stand and to allow for them in calculating the true time of observation of a pendulum.

The oscillation of the stand and pillar has the effect of retarding the vibrations of the suspended pendulum, and the intensity of the force of gravity being directly deducible from the observed time of

vibration is given too small. Thus it has come about that the observations of 1904 have shown those of 1866 to be incorrect.

The pendulum station of the old series which attracted most attention was that of Moré. This station situated on a plateau in the Western Himalayas at an elevation of 15,400 feet was included in the original programme at the request of the late Sir George Stokes. Basevi's observations indicated that at Moré the actual intensity of the force of gravity was 0.518 in defect of the value which geodesists had predicted from theory.

This extraordinary result could only be explained on the hypothesis that there was a deficiency of matter underlying Moré equivalent to 14,700 feet of the mountain mass. The visible excess of rock standing above the sea level at Moré being 15,400 feet, and the hidden deficiency being equivalent to 14,700 feet, the actual excess of mass in the Earth's crust under this high Himalayan plateau was according to Basevi's result only 700 feet.

It was partly owing to this observation that the Himalayas were supposed to be "compensated," and that the idea was formed that the great masses which we see towering above the horizon are more apparent than real. Archdeacon Pratt, whose mathematical knowledge was for so many years of service to the Survey of India, was the author of the celebrated theory that the amount of matter in all parts of the Earth's crust is the same, or, to use his own words, "that in the land portions of the Earth's surface there is a deficiency of matter below the sea level approximately equal to the amount of matter above it; and that below ocean beds there is an excess of matter approximately equal to the deficiency of matter in the ocean as compared with rocks."

Whether this theory will be generally confirmed by future pendulum observations it is too early to say; but recent investigations in India, both of the plumb-line and the pendulum, have shown that the original data on which it was based are untrustworthy, and that it is certainly not true of every mountain locality.

Before Basevi left Dehra Dun for Moré he discarded the heavy stand which he had previously employed, and substituted a lighter one of his own design. The swing of the latter, it is thought, must have been more serious than that of the former, and his result at Moré is

consequently regarded as more affected by error than that at Dehra Dun.

The defect of 0.123 in the force of gravity at Dehra Dun (which has now, we believe, been correctly determined by Lenox-Conyngham) corresponds to a deficiency in the subjacent strata equivalent to 3,500 feet of Himalayan rock: that is to say, if the crust of the earth were made homogeneous, Dehra Dun instead of being at a height of 2,200 feet above sea level would be 1,300 feet below it.

In 1904-05 Lenox-Conyngham took pendulum observations along a line extending from Cuttack in Orissa across the Ganges Valley to Darjeeling and the hills to the north.* He again found a deep deficiency at the foot of the Himalayas. His pendulum station at Siliguri is similar to that of Dehra Dun in being within a few miles of the foot of the hills. There is however this difference that the height of Siliguri above sea level is only 400 feet.

The theoretical and observed values of gravity were here found to be

The normal or theoretical force	979.049
The force of gravity as observed at Siliguri	978.918
Deficiency of the actual force below the normal	0.131

This deficiency is even larger than that at Dehra Dun: it indicates that 3,700 feet of rock are absent from the crust at Siliguri, so that in an homogeneous section Siliguri would be situated 3,300 feet below sea level.

When we ascend from the plains to the outer hills, we find that the deficiencies of gravity tend to remain constant. At Mussooree, a station on the outer range of the Himalayas, the defect is similar to that at Dehra Dun but not quite so great; Mussooree is 6,900 feet above sea level, and this apparent excess of rock is compensated to the extent only of one-half.

The deficiency of gravity observed at Darjeeling in the hills north of Siliguri is 0.143. This last result differs but slightly from that obtained at Siliguri. Darjeeling is 7,000 feet higher than Siliguri, and this great excess of rock which rises so abruptly from the plains is not

* The values of the intensity of the force of gravity as determined in 1904-05 have not as yet been *finally* computed; the values given in this report must therefore be regarded as preliminary.

accompanied by any increase in the compensating deficiencies of the underlying strata.

The highest station visited by Major Lenox-Conyngham was Sandakphu, a point 35 miles from Darjeeling and 11,800 feet high: at this place gravity was found to be 0.149 in defect. This is a very different result from that obtained at Moré: it shows that the height of Sandakphu, would still be about 7,600 feet if all its underlying strata were condensed to normal density.

To the south of the great dip which has been found to exist along the foot of the mountains a considerable excess of mass has been discovered. From Siliguri southwards and from Dehra Dun southwards the deficiency in the force of gravity is observed slowly to disappear: 110 miles south of Siliguri, and 200 miles south of Dehra Dun the force of gravity is in excess.

The lines of pendulum stations that run south from Siliguri and Dehra Dun traverse the flat alluvium of the Ganges Valley, and there is nothing at the surface to indicate that the amount of matter in the crust is slowly increasing with the distance from the Himalayas.

It may be questioned whether the existence of alluvium tends in any way to decrease the intensity of the force of gravity: superficial alluvium is somewhat lighter than rock, but even at moderate depths the difference in their densities disappears. In the centre of the Ganges Valley, where the alluvium is presumably deepest, gravity is not in defect: it is along the northern edge of the alluvium that the maximum deficiencies of gravity have been discovered.

The number of results that are at present available for discussion are too few to justify any theory of Himalayan structure being formulated. All that we are now able to say is that the outer ranges of the Himalayas are partially but by no means completely compensated: that there is a great deficiency of matter at the foot of the hills, and that further south the deficiency disappears and gives place to an excess.

As to the constitution of the higher Himalayan ranges and plateaux we know nothing; nor have we any idea as to whether the lesser ranges of India, the Nilgiris, the Aravallis, the Vindhya, and the Ghats are compensated or not.

In February 1905 Professor Hecker, of Potsdam, joined Major Lenox-Conyngham's camp in Bengal: this officer had been deputed by the International Geodetic Association to observe the force of gravity over the great oceans. In the course of his work he reached Calcutta, and took the opportunity to compare his pendulums with those in use in India. Professor Hecker and Major Lenox-Conyngham observed their pendulums simultaneously on several days at Jalpaiguri: their co-operation has furnished us with the means of making a valuable comparison between the Indian pendulums and the Potsdam Standard.

Tidal Operations.—Throughout the past year tidal observations have been taken at the nine following observatories:—Aden; Karachi; Okha, in the Gulf of Cutch; Bombay (Apollo Bandar); Bombay (Prince's Dock); Madras; Kidderpore; Rangoon; Port Blair.

Of these Kidderpore and Rangoon are riverain stations, Okha is a gulf station, and the remainder are open-coast stations.

The total number of Indian tidal observatories which have been in operation at one time or another, and for which predictions are now annually calculated, is 42. Of these 33 have now been closed. It is not easy to tell whether our predictions for all the closed observatories are continuing to be satisfactory or not: at four ports only are predictions tested, and the method of testing is by means of graduated tide-poles which afford no reliable criterion. Of recent years the tests applied at Moulmein have not been considered sufficiently accurate and the re-opening of the observatory is under consideration. The times and heights of high and low water are largely influenced by the configuration of the coast, and at ports situated like Moulmein, near the mouths of large rivers, the movements of shoals interfere with accuracy of prediction if the data employed are old.

In former years the calculations of the predictions were postponed until the most recent observations were to hand, but under that system the published tide tables were frequently not ready in time: in 1903 the plan was adopted of calculating predictions three years in advance, and the data for the tide tables of 1907 have been already despatched to the Director of the National Physical Laboratory, Teddington, whilst those for 1908 are almost complete.

A tidal observatory was first erected at Okha, in the Gulf of Cutch, in 1874 at the instance of geologists, who desired to ascertain whether the land was subsiding or not. When sufficient observations had been taken to furnish a reliable value of mean sea level for a datum, the observatory was closed. It was re-opened in 1904, and will be again closed down when a further complete year's observations have been recorded.

A line of levels will then be carried from the observatory to some old bench-marks, erected at different distances from the coast, and the data thus obtained will be sufficient to determine whether the height of the land above mean sea level is different to what it was 30 years ago.

At the suggestion of Professor Darwin and Professor Helmert the Malay Peninsula was reconnoitred in 1904 by Mr. H. G. Shaw. It was hoped that a suitable site for a tidal observatory might be discovered on each side of the peninsula. The object of the scheme was to test by means of a line of levels carried across the peninsula from one tidal observatory to the other whether the mean level of the ocean was the same on both sides. Mr. Shaw could however find no suitable place for a tidal station; numerous islands exist which impede the progress of the tidal waves, as they approach the coasts; the fore-shores are shelving: between high and low water the sea recedes to a great distance; and the only villages where tidal observers could live are situated on narrow creeks, in which the mean level of the water differs from the mean level of the ocean; the scheme has had consequently to be abandoned.

The observations at Suez and Perim taken between 1897 and 1903 showed that in some ways the tides of the Red Sea were peculiar and abnormal, and Professor Darwin has suggested that an intermediate tidal station at Suakim would be valuable. The present inaccessibility of Suakim renders the erection and annual inspection of a tidal observatory somewhat difficult to arrange for. If Suakim were connected by railway with Cairo the difficulty would disappear, but it is at present doubtful whether the railway that has been projected will not avoid Suakim altogether and join the Red Sea further north. It is therefore not considered advisable to formulate any tidal scheme until the terminus of the railway has been selected.

ON THE GEOGRAPHY OF TIBET.

BY

LIEUT.-COLONEL S. G. BURRARD, R.E., F.R.S.

Within the last few years large areas of the Earth's land-surface have been brought for the first time under survey. During the Somaliland Expedition of 1903 Captain Beazely was able to carry out important surveys. In 1903 and 1904, when the boundary between Aden and Turkish Arabia was being defined by a Commission, Captain M. O'C. Tandy surveyed a portion of South-Western Arabia that had never been previously mapped: and between 1903 and 1905, during the progress of the Seistan Mission, Mr. G. P. Tate made valuable surveys of the inland delta of the Helmand, a little known but very interesting region of Central Asia.

The reports on these surveys in Africa, Arabia and Central Asia have not as yet been published, and it is therefore necessary to postpone till next year any discussion of the geographical results obtained.

In 1904 Major Ryder, D.S.O., and Captain Cowie accompanied the Tibet Mission to Lhasa as survey officers. On the return of the mission to India Major Ryder and Captain Wood carried surveys westward through Tibet along the valley of the Brahmaputra. Major Ryder's maps of Southern Tibet were published in 1905, and form an important contribution to trans-frontier geography.

The existing maps of the Himalayas and Tibet vary from mere compilations of explorers' routes to skilled representations of country. There are fundamental differences between an exploration and a survey: in an exploration there is no basis of triangulation and the narrow route of the explorer is all that is measured; the only heights determined are of places actually visited and inferior methods are used: the map as produced is a skeleton showing the courses of rivers followed, the positions of towns visited and passes crossed.

In a survey the measurements are controlled by a fundamental triangulation; they are extended over a wide area instead of being confined to a line; the heights and positions of all peaks, whether visited

or not, are determined trigonometrically; and the map as produced shows the features, the inequalities and the relief of the surface.

The areas surveyed by Major Ryder and his colleagues had been previously explored by native surveyors, and the sources and courses of the great rivers were known. The Brahmaputra in Tibet was known to be remarkable amongst the rivers of the world for the great elevation of its bed, for the straightness of its course, for the narrowness of its trough, for the paucity of its feeders. *Major Ryder's aim was therefore to survey not to explore.* The exploration of a new country attracts the attention of the public, but the task of the surveyor, who has to observe from the summits of peaks and represent all the details of valleys and ranges on paper, is incomparably harder than that of the explorer, who follows a certain route to discover the source of a certain river. The explorer ascertains a few facts whose novelty renders them interesting, the surveyor contributes a permanent addition to the mapping of the world.

5. So long as Tibet was an unknown country it was advantageous to push explorations, and in the latter half of the last century the native explorers of the Survey of India accumulated valuable information concerning the plateau.

But we have now got out of exploration all that it can give us, and our knowledge of the country will not advance further until we undertake systematic surveys, topographical and geographical, and open regular meteorological observatories. The only region of Tibet in which there is still, perhaps, a use for geographical exploration is the wild country lying towards Burma and China. That the Sangpo river of Tibet falls into the Brahmaputra is a fact conclusively established, but the upper courses of the great rivers of Burma and Siam are still unknown.

Complete ignorance also prevails as to the form of the Karakoram range in its extensions across Central Tibet, and as to how the long parallel folds of the Himalaya Mountains merge eventually into the oblique and diverging chains of Burma and China; but these orographical problems will never be solved by exploration: an explorer can trace a river but not a range.

The central portion of Tibet is composed of a vast number of lakes which have no connection by river with the sea. A survey of these lakes would be valuable, but nothing would be gained by their exploration.

These lakes are supposed by some writers to be drying up, but if that is the case, it is difficult to understand why the process of desiccation should be so prolonged. Though the plateau of Tibet is in its geological youth, it has been in existence for some millions of years, and it is not unreasonable to suppose that the present level of the water in the lakes of Tibet is the final effect of the two opposite processes of evaporation and precipitation after long ages of operation—an effect that will continue so long as the present meteorological conditions remain unchanged. It is useless, however, to speculate on any such question until the fragmentary and casual notes of travellers have been replaced by systematic meteorological observations.

The limits of the catchment basin of the Sutlej.—The twin lakes of Manasarowar and Rakas Tal are the most famous of the lakes of Tibet, and their connection with the drainage of the Sutlej is an interesting hydrographical question. In the mountains surrounding these lakes four great rivers have their rise—the Indus, the Sutlej, the Karnali and the Brahmaputra. There is a stream connecting the two lakes, which Henry Strachey described in 1846 as “100 feet wide and 3 feet deep, running rapidly from east to west through a well-defined channel.” In December 1904 Major Ryder wrote of this channel as follows:—“No water was flowing at this time of the year, but the local Tibetans all agreed that for some months in each year there was a flow during the rainy season and the melting of the snows.”

There is also a connecting channel between the westernmost of the two lakes and the main source of the Sutlej: but though there are numerous signs that water has flowed in recent times from the lakes into the Sutlej, yet no known observer has actually witnessed a flow. It may be that the two lakes send off feeders into the Sutlej whenever their water is high, and this was the view taken by Richard Strachey in 1850. Major Ryder writes: “We found an old stream bed issuing from the Rakas Tal, but every Tibetan we asked told the same story—that no water ever flowed along it now, but that in days gone-by, one

"man saying before the Sikh War, water did flow out of the lake "and down this channel."

It will be an interesting problem to solve whether the Manasarovar and Rakas Tal lakes still continue in seasons of flood to form part of the catchment basin of the Sutlej, or whether they have permanently ceased to do so.

The Tibetan name for Mount Everest—In the course of his work in Tibet Major Ryder endeavoured to ascertain whether the Tibetans had any name for Mount Everest. Mount Everest is situated in Nepal and, as seen from Southern Tibet, is a very prominent peak. When in 1852 it was discovered from the side of India to be the highest mountain in the world, its great elevation was not suspected by the natives of Nepal, and it was not known by a local name. It stands remote from beaten tracks, it is not exposed like Kinchinjunga to the vulgar gaze of man, it marks no goal of pilgrimage like Gangotri or Badrinath.

With the approval of Lord Dalhousie it was given the name of Everest; it was so called after the great mathematician who was the founder of systematic geography in Asia, and who created for the Indian surveys their permanent basis of triangulation.

In 1853 Mr. Hodgson, the Resident in Nepal, raised objections to the name of Everest and maintained that the peak was well-known to the Nepalese under the name of Devadhunga. In 1854 Herman Schlagintweit, a professional geographer, visited Nepal, saw Mr. Hodgson's peak, and discovered that its name was Gaurisankar. These names of Devadhunga and Gaurisankar continued to have advocates for many years, but in 1903 Captain Wood, R.E., made careful observations with a theodolite in Nepal, and found that Hodgson and Schlagintweit had mistaken a nearer peak for Mount Everest.

Of recent years a Tibetan name, Jhomokangar, has been advocated for Mount Everest by Sarat Chandra Das, Mr. Freshfield and others: but the identification rests on no direct evidence. A high peak named Jhomokangar has been mentioned by Tibetans, and from the reports of the latter it has been considered possible that this may be Mount Everest: but no one of the advocates of the new Tibetan name has ever had Mount Everest pointed out to him as Jhomokangar by

Tibetans. When Major Ryder was in Tibet he saw Mount Everest from many points: he subjected his identification of the peak to careful tests with theodolites, and he thus ran no risk of mistaking another peak for it. He was able to point Mount Everest out to Tibetans and ask them the question—"What is your name for that peak?" He found always that they had no name.

In a map published in 1872 to illustrate the explorations of Kishen Singh a mountain was marked Jhomogangar in Tibet, 215 miles north-east of Everest: this name of Jhomogangar has been printed on all subsequent maps of the region. In the account of Kishen Singh's explorations occurs the following passage:—"On January 6th "they reached Dung Chaka 15,700 feet above sea level. About ten miles "to the east there is a lofty snowy peak called Jhomogangar, some- "what of the same shape as the Kailas peak near Manasarowar: it "is a noted object of worship, being considered a female divinity." Kishen Singh was a reliable explorer; his word may be accepted that a sacred mountain exists in Central Tibet that is known by the name of Jhomogangar.

Major Ryder's investigations have finally disposed of the last phase of this question. Neither in Tibet nor in Nepal is Mount Everest known to the inhabitants by any native name.

The highest mountain of Asia.—In 1884 a mountaineer of great enterprise named Graham stated that he had discovered two peaks which he believed to be higher than Mount Everest. He and his companion saw these peaks from a very high point on one of the spurs of Kinchinjunga. Mr. Graham described his supposed discovery as follows:—

North-west, less than 70 miles, lay Mount Everest, and I pointed it out to Boss, who had never seen it, as the highest mountain in the world. "That it cannot be," he replied: "Those are higher"—pointing to two peaks which towered far above the second and more distant range, and showed over the slope of Everest—at a rough guess some 80 to 100 miles further north. I was astonished, but we were all agreed that in our judgment the unknown peaks, one rock and one snow, were loftier.

Mr. Graham had no instruments with him: he trusted to his eyesight he estimated distances and heights. When we consider the great difficulty of identifying any particular peak amidst the myriads

of its companions without the aid of a theodolite; and when we reflect on the inferiority of the human eye as a range-finder, it becomes a subject for wonder that Mr. Graham's alleged discovery should have been accorded the weight that it has.

The distance of Everest from Kinchinjunga could, of course, be obtained from maps, but to suppose that the human eye unaided is capable of estimating a distance of 170 miles is to go against all experience.

It is more than probable that Mr. Graham failed to identify Mount Everest. Mount Everest does not lie north-west from Kinchinjunga as he thought. It was 77 miles from Mr. Graham's supposed position and not less than 70 as he believed: and if the two higher peaks had been 100 miles *further north*, they would not have appeared over the slope of Everest as he stated, but in a different direction altogether.

Major Ryder's route along the Brahmaputra passed 80 miles north of Mount Everest, and he found no peak approaching Mount Everest in height. The highest peak that he discovered in this part of the country was 8,000 feet lower than Everest.

A traveller who visits Tibet and the Himalayas for the purpose of discovering a mountain higher than Mount Everest has a very poor chance of success. The high peaks of Asia group themselves into two chains, the Himalayan and the Karakoram: and these chains throughout their lengths have been closely scrutinised with theodolites; it is most improbable that the highest mountain of all should have escaped detection.

The whole plateau of Tibet has been intersected by the routes of travellers, and no point on it can now be found that is as much as 80 miles from the track of an explorer. A mountain 30,000 feet in height requires a great elevated base to rest upon; a 30,000 feet peak must be the culminating point of a great range; it must be surrounded by many companion peaks, only less lofty than itself, and it will be visible from a distance of 200 miles. Yet no one of the travellers and explorers who have traversed Tibet has described a mountain mass rivalling Everest or K².

Nevertheless we cannot state definitely that there is no peak in existence of 30,000 feet. Until Tibet has been systematically surveyed,

we shall have to confine ourselves to the consideration of probabilities; explorers have no means of measuring the heights of inaccessible points, and may be possibly misled in a region of scanty snow-fall by the naked appearance of lofty summits. If however we note the geographical distribution of the great peaks—if we regard the configuration of the Tibet plateau, compressed on the west and widening eastward—and if we consider that the central portion of Tibet is a lake region in which no river has been developed, we are justified in concluding that the existence of a higher mountain than Everest is extremely improbable.

It has been argued that experienced explorers are able to estimate the heights of unknown peaks within a thousand feet. But the mistakes that are constantly being found in the estimated values of heights, when trigonometrical measurements come at last to be taken, show how valueless conjectural geography is.

In his well-known work on Ladak Sir Alexander Cunningham wrote as follows:—"A single peak to the northward of Sassar was estimated by Dr. Thomson at 24,000 feet. The estimate may be perhaps a little too high, but I have great confidence in the accuracy with which a practised eye may measure heights."

Yet Sir Alexander Cunningham himself estimated the height of Nanga Parbat to be 19,000 feet: its correct height is 26,629. In this case the error of conjectural geography was 7,629 feet.

Gerard estimated some of the peaks in Lahoul and Spiti to be 30,000 feet—8,000 feet too great: and many other examples could be quoted to prove that eye observations are worthless.

Summary of Major Ryder's results.—A comparison between Major Ryder's maps and those of the old native explorers has proved the latter to have been accurate and trustworthy observers. They were never able to use instruments openly, and it is wonderful how they measured their routes at all. They were taught to observe for latitude, and their observations were good, but it is doubtful whether they ever knew what a latitude meant. They had no means of checking their longitudes.

Major Ryder found that the towns of Lhasa and Shigatse had been placed on our maps 8 miles too far west: the position of Gartok was however correct to within half a mile. The barometric heights

observed by the explorers were found to be at Lhasa too small by 490 feet, at Shigatse too small by 500 feet, at Gartok too small by 100 feet, at Gyantse by 50 feet, and at the Ma-yum pass by 1,400 feet.

The fundamental difference however between an exploration and a survey is not a question of accuracy; an exploration furnishes a map of a line, a survey furnishes a map of an area. The survey results obtained by Major Ryder may be summarised as follows:—Triangulation was executed connecting Lhasa with India, and fixing all prominent peaks; the country was surveyed on the scale of 4 miles to the inch; on the same scale the whole valley of the Brahmaputra was surveyed from Shigatse to its source; the Manasarowar lake region was surveyed, as also the source of the Gartok branch of the Indus, and the Tibetan course of the Sutlej; the total area surveyed with the plane-table amounted to 60,000 square miles. The survey of the Brahmaputra was carried through with great expedition and in the face of many difficulties: the field work was performed at an average elevation of 16,000 feet and in a climate of Arctic severity.

BOTANICAL SURVEY.

BY

CAPTAIN A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.

Acting Director, Botanical Survey of India.

Eastern India.—This, which for Botanical Survey purposes is under the Superintendent of the Royal Botanic Garden, Calcutta, comprises Bengal, the North-Eastern Frontier, Eastern Bengal and Assam, Burma, and the Andaman and Nicobar islands.

In Bengal collections mostly of monocotyledonous plants were made in the Jashpur and Sirguja districts of Chota Nagpur by native collectors working under the kind supervision of the Rev. Father Cardon. Mr. H. H. Haines of the Forest Department contributed to the Calcutta Herbarium a small collection made in the Singbhum district of Chota Nagpur, while the Survey is indebted to Captain C. J. Robertson-Milne, I.M.S., for a representative set of plants from Orissa. The collections made in 1903-04 along the route of the Mission to Tibet, continued

to be supplemented in 1904-05 by additional collections made up to the neighbourhood of Lhasa itself. The Tibetan collections are being elaborated in Europe by Lieutenant-Colonel Prain, I.M.S., but there has not yet been sufficient time to allow of the publication of the results. Advantage was taken of the Road survey operations in connection with the opening up of the Chumbi valley to send up a couple of trained Lepcha collectors, whose work was supervised by Mr. G. L. Searight the officer in charge of the Road Survey. The collections made by the Calcutta Garden collectors in the Chumbi valley were supplemented by collections made by Mr. E. H. C. Walsh, I.C.S. and Mr. J. C. White, C.I.E.

There has not yet been any opportunity of completely working out those collections, but one of the results of the exploration of the Chumbi valley has already proved of considerable interest to botanists and horticulturists alike. This is the re-discovery of the much discussed orchid *Cypripedium* or—as it is now called—*Paphiopedilum Fairieanum*, and its re-introduction to cultivation in Europe, to which it had been almost entirely lost for about thirty years. The species was found growing on an exposed situation at an altitude of 3,000—4,000 feet in the valley of the Amu Chhu, or Torsa river. In Sikkim collections were made by Mr. B. B. Osmaston, Deputy Conservator of Forests, while the usual expedition was made by the Curator of the Lloyd Botanic Garden, Darjeeling, to the high levels for seeds of the plants growing at such altitudes for distribution from the Calcutta Botanic Garden to the chief botanical institutions of Europe and America. From British Bhutan collections made by Mr. J. C. White, C.I.E. and Mr. H. H. Haines were presented by them to the Calcutta Herbarium.

In Assam collections were made in the district of Sylhet to link up with those made in the previous year in the adjacent district of Cachar. A collection from Goalpara was also sent by Mr. James Marten, of the Forest Survey. In Burma a collector from the Calcutta Botanic Garden worked over Tenasserim. From the same district the Forest Department sent, as usual, some very interesting collections, which have yielded several new species, and one new genus of a somewhat

aberrant character representing a new tribe of the natural order Sterculiaceae. This latter has been named *Mansonia*, in honour of Mr. F. B. Manson, lately Conservator of Forests, Tenasserim circle, who has all along given willing help in botanical survey work.

From Lower Burma Mr. J. H. Lace, Conservator of Forest, Pegu circle, sent a collection to the Calcutta Herbarium. From the Shan hills some noteworthy orchids have been sent to the Calcutta Garden, including such species as *Cypripedium Charlesworthii* and *Cypripedium bellatulum*.

Mr. I. H. Burkill, Reporter on Economic Products, when in Burma made, with the aid of the Forest Department, important collections of the genus *Calamus*. He also brought back an interesting collection of fresh water algae which were sent to England to Mr. W. West, the authority on this group, for description and publication.

Mr. Gilbert Rogers, Deputy Conservator of Forests, Andamans, has made collections in the Andaman islands and on Narcondam island, the latter supplementing the collection made on a previous occasion by Lieutenant-Colonel Prain. Mr. Lace has also sent to the Calcutta Botanic Garden a collection from the Andamans. The opportunity afforded by a visit of the Chief Commissioner of the Andamans to the Nicobar Islands was utilised by sending by his kind permission a native collector from the Calcutta Botanic Garden to accompany his party.

Western India.—During the hot weather vacation Mr. Bhide, then in officiating charge of the botanical survey of Western India, completed a collecting tour from Kohalpur to Ratnagiri *via* Amba Ghât, returning *via* the Phonda Ghât. During the cold weather vacation Mr. G. A. Gammie collected over parts of Guzerat and the Khandesh district. Mr. G. M. Ryan, of the Forest Department, completed his collection of plants of the Thana district preparatory to elaborating them for publication conjointly with Mr. G. A. Gammie.

In Baluchistan excellent collections were made by the Seistan Arbitration Commission under the direction of Colonel the Honourable A. H. McMahon, C.S.I., C.I.E., who has generously presented them to the Royal Botanic Garden, Calcutta. Mr. R. Hughes-Buller has also made valuable collections in the same province.

Southern India.—From Travancore Mr. T. F. Bourdillon, Conservator of Forests, has contributed a small collection to the Botanical Survey. In the same district a tour was made along the backwaters by one of the assistants of Mr. Barber, Madras Government Botanist, more especially to collect indigenous Indigoferas. Another tour was made along the chief Sandal bearing tracts of Mysore for the formation of a Sandal flora. Mr. Barber himself collected at various places in the Madras Presidency when on tour in connection with his economic work. The flora of Ganjam, including the peculiarly interesting flora of Mahendragiri, a hill which reaches an altitude of nearly 5,000 feet, has been collected and studied by Mr. C. E. C. Fischer of the Forest Department, now in Coimbatore. Collections have also been made in the Godávári district by Mr. G. F. F. Foulkes, the district Forest Officer.

General.—From the foregoing sketch it will be gathered that, except in Upper, North-Western and Central India, a considerable amount of exploration has been done. Most of the collections have gone to the Herbarium of the Calcutta Botanic Garden, where they are being worked up as opportunity permits, although owing to the very inadequate staff progress is necessarily slow. During the year Mr. Duthie, late Director of the Botanical Department of Northern India, sent out another instalment of his Flora of the Upper Gangetic Plain, bringing the work up to the end of Campanulaceae. This, which completes Vol. I of the Flora, was in the Press at the end of the year under review. The Flora of the Presidency of Bombay by Dr. T. Cooke, C.I.E., also advanced a stage during the year, Part I of Vol. II, giving an account of the natural orders from Compositae to Boraginaceae, being published in May 1904. During the year Mr. J. R. Drummond, I.C.S., of the Punjab Commission, since retired, was engaged in the Calcutta Herbarium on the preliminary work in connection with his projected Flora of the Punjab. The elaboration of materials for a Flora of the Malayan Peninsula, based upon the collection belonging to the Calcutta Herbarium, was continued by Sir George King, K.C.I.E., and Mr. J. S. Gamble, C.I.E., and fasciculus No. 15, containing a description of twenty-four genera of the natural order Rubiaceae, was published.

To consider the Botanical Survey from another side, the following natural orders and genera have been studied during the year :—

The Orchidaceae of the North-west Himalaya have been made by Mr. J. F. Duthie the subject of a monograph which is in the Press and will, it is hoped, soon appear as Part II of Vol. IX of the Annals of the Calcutta Botanic Garden.

The Piperaceae of India as represented in the Calcutta Herbarium are under study by M. Casimir de Candolle, the distinguished Botanist of Geneva, to whom also has been sent the Calcutta material of the Meliaceous genus *Cedrela*. The Calcutta specimens of the natural order Amarantaceae have been under examination by Dr. Hans Zchinz, Director of the Botanical Gardens of Zürich. The Aconites of India have been the subject of special study by Dr. O. Stapf, of the Kew Herbarium, who has written a very valuable monograph on the genus, forming Part II of Volume X of the Annals of the Royal Botanic Garden, Calcutta.

The Indian and Malayan species of the genus *Impatiens* have been revised and epitomised by Sir Joseph Hooker, G.C.S.I., and the first part of his *Epitome* has appeared in the Records of the Botanical Survey during the year, while the continuation was in Press at the end of it. The Calcutta material of the genus *Nepenthes* was sent to the Director of the Royal Botanic Gardens, Kew, to be studied by Mr. Hemsley, F.R.S., the Curator of the Kew Herbarium. Various collections of climbing palms (*Calamus*) were sent to Signor Odoardo Beccari of Florence, who is the authority for this group of plants. His monograph on the genus which is to form a volume of the Annals of the Royal Botanic Garden, Calcutta, was sent to Press in the course of the year.

To Signor Ugolino Martelli was lent the *Pandanus* material belonging to the Calcutta Herbarium, to aid him in the preparation of his work on that genus.

Publications.—The official publication of the Botanical Survey of India as a Department is entitled "The Records of the Botanical Survey of India." Although only one of the two officers who constitute the scientific staff of the Calcutta Botanic Garden is an officer of the Botanical Survey, yet the official publication of

the Survey is almost entirely supported by the Calcutta Garden and its correspondents. Of the Records three parts have been published during the year, entitled as follows :—

Vol. III. No. 1. The Vegetation of the district of Minbu, in Upper Burma, by A. T. Gage (pp. 141, with map).

Vol. III. No. 2. The Vegetation of the districts of Hughli-Howrah and the 24-Pergunnahs, by D. Prain (pp. 198, with map)

Vol. IV. No 1. An Epitome of the British Indian species of Impatiens. Part I., by Sir J. D. Hooker, F.R.S., G.C.S.I.

Papers not published departmentally bearing on the Botany of India comprise the following, of which Part I of Vol. II of the Flora of the Presidency of Bombay, by Dr. T. Cooke; the paper by Sir Joseph Hooker on the species of Impatiens in the Wallichian Herbarium of the Linnean Society: and Sir George King and Mr. Gamble's No. 15 of Materials for a Flora of the Malayan Peninsula are the more important.

A list of papers published during 1904-05 bearing on the Botany of India.

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| BOURDILLON, T. F. | . Eugenia Rama-Varma, a new species. <i>Indian Forester</i> , xxx, No. 4, p. 147. |
| BOURDILLON, T. F. | . Eugenia occidentalis, a new species. <i>Indian Forester</i> , xxx, No. 5, p. 195. |
| BOURDILLON, T. F. | . Dialium travancorium, a new species. <i>Indian Forester</i> , xxx, No. 6, p. 243. |
| BOURDILLON, T. F. | . On two species of black wood found in Southern India. <i>Indian Forester</i> , xxxi, No. 3, p. 124. |
| BRANDIS, SIR D. | . Linderia aromatica. <i>Hook. Icones Plant.</i> viii, t. 2784. |
| BURKILL, I. H. | . See <i>Prain</i> . |
| COOKE, T. | . Flora of the Presidency of Bombay. Vol. II, Part I. Compositæ—Boraginaceæ. |
| DRUMMOND, J. R. | . On a new Scirpus from Baluchistan and certain of its allies. <i>Journ. As. Soc., Bengal</i> , lxxiii, pt. ii, 1904, pp. 137—148. |

- FINET ET GAGNEPAIN . Contributions à la Flore de l'Asie orientale.
Bull. Soc. Bot. de France, li. pp. 388, 461.
- FISCHER, C. E. C. . Notes on the Flora of Northern Ganjam.
Journ. Bombay Nat. Hist. Soc., xv, No. 4, p. 587.
- GAGNEPAIN, F. . . Zingiberacees et Marantacees Nouvelles.
Bull. Soc. Bot. de France, li. No. 4, p. 164.
- GAMBLE, J. S. . . See *King*.
- HEMSLEY, W. B. . . Loropetalum chinense. *Bot. Mag.*, 3rd Series, lx, t. 7979.
- HEMSLEY, W. B. . . Rosa gigantea. *Bot. Mag.*, 3rd Series, lx, t. 7972.
- HEMSLEY, W. B. . . Dendrobium Williamsoni. *Bot. Mag.*, 3rd Series, lx, t. 7947.
- HEMSLEY, W. B. . . Vanda pumila. *Bot. Mag.*, 3rd Series, lx, t. 7968.
- HEMSLEY, W. B. . . Tupistra Clarkei. *Bot. Mag.*, 3rd Series, lx, t. 7957.
- HOLE, R. S. . . A contribution to the Forest Flora of the Jubbulpore Division, C. P. *Ind. Forest.* xxx, pt. 11, p. 499, pt. 12, p. 566.
- HOOKE, SIR J. D. . . On the species of Impatiens in the Wallichian Herbarium of the Linnean Society.
Journ. Linn. Soc., xxxvii, No. 257, p. 22.
- KING, SIR G., AND GAMBLE, J. S. . Materials for a Flora of the Malayan Peninsula, No. 15, *Journ. Asiat. Soc. Bengal* lxxiii, Part II, No. 3, p. 47.
- MAHALUXMIVALA, C. D. . Notes on some of the plants introduced into the Victoria Gardens, Bombay, during the past eight years. *Journ. Bombay Nat. Hist. Soc.*, xv., No. 4, p. 674.
- MARTELLI, U. . . Pandani Asiatici nuovi. *Bull. Soc., Bot. Ital.*, 1904, No. 6, p. 298.

- PRAIN, D. An undescribed Indian Musa. *Journ. Asiat. Soc., Bengal*, lxxiii, Part II, No. 1, p. 21. (Noviciæ Indicæ XXI).
- PRAIN, D. An undescribed Araliaceous Genus from Upper Burma. *Journ. Asiat. Soc., Bengal*, lxxiii, Part II, No. 1, p. 23, with plate. (Noviciæ Indicæ XXII).
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AGRICULTURAL BOTANY.

BY

E. J. BUTLER, M.B., F.L.S.

Cryptogamic Botanist to the Government of India.

Cereals and food stuffs.—The office of the Reporter on Economic Products has carried nearly to completion the botanical study of the varieties of *juar* (*Andropogon Sorghum*) grown in India, and the report will soon be ready for the Press. The extent of this inquiry may be grasped from the fact that in Madras alone the Government Botanist has accumulated 680 sheets of specimens, exclusive of sorghum diseases. The investigation of the plants yielding yams, carried on in the same office in collaboration with the Superintendent, Royal Botanic Garden, Calcutta, has also advanced. Similar inquiries on chillies, plantains and Burmese pulses are in progress in the Reporter's office, and the information obtained regarding the latter is almost ready for publication. The Government Botanist, Madras, is engaged on a detailed study of the different varieties of sugarcane at the Samalkota sugar station, which has been enlarged and made permanent during the year. This inquiry includes not only the botanical characters of the varieties but also their agricultural value as regards yield, purity of juice and resistance to red rot. Some Mauritius canes imported into Vizianagram a few years ago were tested both at Samalkota and Pusa, and gave excellent results. Some Barbados seedlings have also been

introduced at Samalkota and their acclimatisation is being attempted. It has been established by Mr. Barber that some of the canes which flowered at Samalkota produced fertile seeds; this opens a way to experiments in the production of seedling canes which have proved so successful in other countries. The Reporter on Economic Products has in hand investigations of the Indian varieties of caraway (*Carum*), pan (*Piper Betel*), barley, wheat, Goa bean, and the rice known as *Oryza coarctata*. Collections of edible mushrooms are being made at the Indian Museum and by the Cryptogamic Botanist working conjointly. A list of famine foods is under preparation in the office of the Reporter. The scientific study of groundnut and black pepper, both of which important crops in South India are falling in cultivation mainly owing to fungus disease, has been provided for by the founding of two experiment stations by the Madras Government. One of these at Palur, in South Arcot, is intended for groundnut and subsidiary crops, and the other at Taliperamba, in Malabar, for pepper. They have been placed under the general control of the Government Botanist, Madras. Professor Wyndham Dunstan, Director of the Imperial Institute, London, has issued a report on the poisonous properties of Lima bean (*Phaseolus lunatus*), which has been published in the Agricultural Ledger for 1905. His results go to show that while the semi-wild forms grown in Mauritius contain considerable quantities of a glucoside, yielding prussic acid on fermentation, cultivated forms from Burma possess a lesser but variable amount. He recommends the cultivation of the white variety of bean as being the least dangerous in this respect. Major Buchanan's report on the disease known as lathyrism in India, produced by eating *Lathyrus sativus*, has not yet been published.

Fibres.—The study of cotton, with a view to the extension and improvement of cotton cultivation in India, has attracted a great deal of attention during the year. A detailed account of the work in progress in the several Agricultural departments was published in the Proceedings of the Board of Agriculture in India, in January 1905. The present series of correlated experiments in nearly every Province of India may be considered to have originated in 1902, when the Inspector-General of Agriculture in India collected as complete a set as possible of the existing varieties, submitted them to a preliminary examination and

distributed them to the experiment stations of the principal cotton tracts as a basis for further study. The botanical investigation of Indian cottons was taken up by Professor Gammie; and his second paper, dealing with the species and varieties known in India, their respective areas of distribution, the important question of the degree to which hybridization naturally occurs, the quality of the lint and other similar matters, is now in the press. Mr. Burkill toured in Burma and the Nizam's Dominions for the purpose of studying the cottons of these tracts, and has submitted to Government two notes on the results obtained. In Burma he distinguishes six kinds, and possibly a seventh, two only being of importance, and furnishes notes on their distribution, cultivation, value and the disposal of the produce. The Inspector-General of Agriculture issued a report on the possibilities of extending cotton cultivation in Burma, in which the economic conditions governing the question are dealt with, and proposals are made for testing the behaviour of native and exotic varieties in the different soils of the dry zone, and for improving the local varieties by seed selection and otherwise. He points out, however, that no establishment exists in Burma for carrying on such work. Two notes have been issued on cotton cultivation in Behar by the Inspector-General of Agriculture and by the Entomologist to the Government of India. The former contains proposals for definite experimental work and a preliminary review of the results obtained in the first two years' trials with Indian and exotic varieties. In Mr. Lefroy's note the behaviour of these varieties during 1904-05 is reviewed and the extent to which they were affected by the climate. Acclimatised Americans gave some small promise of ultimate success. The insect pests of cotton in Behar are also briefly described in this note. Mr. Sly, Officiating Inspector-General of Agriculture, inspected the tree cotton experiments of the Indian Long Staple Cotton Growing Syndicate (agents, Messrs. Shaw, Wallace and Co.) and published a note describing them and suggesting improvements. Attention has recently been directed to this class of cottons—perennials—which are usually found in gardens and temple compounds and the lint of which, sometimes fine in quality, is almost exclusively used for weaving the sacred thread of the higher castes. A large number of varieties has been collected from all parts of India, and these are being tested on a considerable

scale by the Indian Long Staple Cotton Growing Syndicate and on a smaller scale elsewhere. Hybridization of cotton is still in progress at the Bombay Farms and elsewhere, and the results are sufficiently advanced in Bombay to hold out considerable hopes of valuable results. It is already fairly clear that no other line of cotton work equals this in its prospects of ultimate success. The trial of long-stapled Egyptian cottons in Sindh by Mr. Fletcher, Deputy Director of Agriculture, Bombay, has given some promising preliminary results. The continuation of these experiments will be watched with the keenest interest. Fifteen-hundred acres have been sown this year to provide a test on a fairly large scale. Extensive arrangements have been made for the selection of the best seed of local varieties in several cotton tracts, with a view to assisting cultivators to improve their crops. The co-operation of ginning factories has been enlisted in some places, as they can materially assist by separating good seed and issuing it, after ginning, to the cultivators. In other places field-to-field selection is being undertaken. This work is independent of the plant-to-plant selection, which is carried out chiefly on the experimental farms.

Jute investigations, taking their origin in complaints of deterioration in the produce made by the trade some years ago, have been continued during the year and the first stage completed by the issue of a report on "Deterioration of Jute in Bengal" by Sub-Committee B of this Board on September the 19th, 1904. As a result of their inquiries the Sub-Committee report that "there is not only no proof that any deterioration in either of the jute plants has occurred, but there is a strong evidence that the plants are now precisely as they were a century and more ago. The best kinds, now as then, if cultivated liberally, yield excellent crops, and their fibre, if properly extracted, is also excellent. * * * There is no indication that any radical change has come over the system of steeping and retting, but there appears to be proof that at times fraudulent watering, which induces heating and discolouration, is resorted to with the object of fictitiously increasing the weight of the fibre offered for sale." They, however, express the opinion that "though this is no doubt the explanation of some of the deterioration observed and complained of, it does not explain it all; and in their belief the degeneration is largely due to the fact that whereas formerly only the

to which has been ascribed similar diseases in Italy and Japan, but it was not always discovered on diseased plants. Several new coffee diseases have been investigated, one of which, examined locally in the Nilgiris, appears to be very serious. It is apparently caused by a species of *Glœosporium* which attacks the twigs. Experiments in its treatment are in progress. In Sylhet several of the coffee diseases prevalent in South India were found established in an estate visited. The Areca palm plague in the same district was investigated and determined to be due to a fungus attacking the base of the palm, the exact nature of which is not yet known. A report was submitted to the Assam Department of Agriculture from which a vernacular leaflet, giving some suggestions for dealing with it, is in preparation. A serious outbreak of disease in Palmyra, cocoa and areca palms in the Godávári Delta was also investigated, the cause here being a species of *Pythium* which attacks the leaf stalks and terminal bud, thus killing the tree. The inquiry is still proceeding. The disease of sisal hemp due to *Colletotrichum Agaves* has been reported from several districts and was studied in Sylhet. Suggestions for treatment have been given. Two rubber diseases have been examined, the canker of *Hevea* from Burma and a *Botryodiplodia* disease of *Castilloa elastica* from the Anamalis, and treatment recommended. The rust of *juar* (*Andropogon Sorghum*) and *bajra* (*Pennisetum typhoideum*) have been identified and have proved to be distinct species, contrary to the opinion of the late Dr. Barclay. "Green ear" disease of the latter cereal was found to be induced by the attacks of a new species of *Sclerospora* on the leaves. It is still under study. Amongst the most serious diseases reported during the year is the cotton wilt of the Punjab, which appears to be the same as that which has been one of the worst enemies of the cotton cultivation in the United States. The area affected is probably small and efforts will be made to stamp it out, but it must remain for some time a cause of much anxiety. A somewhat similar disease has been found on jute. The mildews which affect a number of Indian crops are being studied by Mr. E. Salmon at Kew, to whom collections have been sent. Tobacco, mulberry, orange, several pulses, castor oil, wheat, coriander and *Trigonella* are amongst the plants attacked.

The poisonous properties of the cereal *kodra* (*Paspalum scrobicu-*

latum) are under study in the Cryptogamic Botanist's office, as there is some reason to believe that they result from a fungus often found in the grain.

The work on wheat rusts carried out in conjunction by the Cryptogamic Botanist and the Deputy Director of Agriculture, United Provinces, was continued. A paper was completed by them in 1904 but has been delayed in publication. This gives details of the chief rusts, considers their mode of transmission from year to year, their specialisation on different host plants and the influence of meteorological conditions on the disease. Mr. Moreland has contributed a note on the latter point based on observations in selected districts of the United Provinces during a number of years. A short note by the Cryptogamic Botanist on the degree to which the liability of wheat to rust depends on secondary infection by Uredospores rather than on the severity of the first outbreak of the disease is in the Press.

The paper on sugarcane diseases in Bengal submitted by the Cryptogamic Botanist in the first half of 1904 has not yet appeared owing to delay in publication. The Government Botanist, Madras, is endeavouring to raise canes resistant to red rot at the Samalkota farm and is continuing his study of the behaviour of different varieties of cane to it.

Mr. A. Nechitsch, of Geneva, has investigated the fungi producing the fermentation of alcoholic beverages prepared from rice in Sikkim and the Khasia hills. The chief fungi concerned are named *Mucor Prainii* and *Dematium Chodati*. Their fermentative activity under different conditions is described.

The preparation of a text book on plant diseases in India has been commenced by the Cryptogamic Botanist.

Miscellaneous.—A large number of references to the economic and agricultural uses of certain plants in Burma and Bengal occur in Vol. 3 No. 1, No. 2 of the records of Botanical Survey of India by Captain Gage and Lt.-Col Prain, respectively.

The use of copper sulphate in purifying tank and well waters by killing algæ and bacteria without injuring the higher forms of life, as described by Dr. Moore of the United States Department of Agriculture, has been extensively tested in India during the year. Dr. Cook, Health Officer, Calcutta, Dr. Turner, Health Officer, Bombay,

Lt. Christophers, Superintendent, King Institute, Madras, and others have issued reports on the results of their trials. Dr. Cook states that he is reluctantly forced to the conclusion that copper sulphate in the quantities prescribed by Drs. Moore and Kellarman is of little practical use for the purification of the filthy tanks that abound in Calcutta. The other workers generally arrive at the same conclusion. Interesting notes are supplied in Dr. Cook's report on the algal vegetation of Calcutta tanks.

The following papers dealing with Agricultural and Economic botany appeared during the year.

1. Proceedings of the Board of Agriculture in India, 1905.
2. Agricultural Ledger No. 2 of 1905, *Phaseolus lunatus* (Lima or Duffin Bean).
3. Note on Cotton Experiments in Behar by J. Mollison.
4. Notes on Cotton in Behar by H. Maxwell-Lefroy.
5. Report on Cotton in Burma by I. H. Burkill.
6. Notes on Cotton made at Bhainsi, Nizam's Dominions, by I. H. Burkill.
7. The cotton experiments of Messrs. Shaw, Wallace & Co. by F. G. Sly.
8. Selected papers on inquiry into deterioration of jute, Government of Bengal.
9. The localization of the Indigo-producing substance in Indigo-yielding plants, by H. M. Leake: *Annals of Botany*, XIX.
10. The occurrence of "hard seed" in *Indigofera arrecta* Hochst, by H. M. Leake: *Journal, Royal Horticultural Society*, Vol. XXIX, pts. 1 & 2.
11. Variation in *Indigofera Sumatrana* Gaertn. as induced by climatic conditions, by H. M. Leake: *Journal Royal Horticultural Society*, Vol. XXIX, pts. 1 & 2.
12. Sisal hemp culture in the Indian Tea Districts, by H. H. Mann and James Hunter. *Indian Tea Association*, No. 3 of 1904.
13. Progress report on the work of the Samalkota Experimental Sugar Farm during 1903-04, by C. A. Barber.
14. Red Rust: a serious blight of the Tea plant, by H. H. Mann and C. Hutchinson, *Indian Tea Association* No. 4 of 1904.
15. Sur les ferments de deux levains de l'Inde, le *Mucor Praini* et le *Dematium Chodati*, by A. Nechitsch, *Institut de Botanique, Université de Genève*, 6e. ser., Ve. Fasc. 1904.

16. Pilzkrankheiten in Indien im Jahre 1903, by E. J. Butler, Zeitschrift für Pflanzenkrankheiten, Bd. XV, Heft 1.

17. Pepper vine disease, by E. J. Butler, Proceedings Wynaad Planters' Association, October 1904.

18. The uses of Copper as an Algicide and Germicide by Dr. J. Nield Cook, Calcutta, July 1905.

FOREST BOTANY.

BY

H. H. HAINES, F.L.S., F.C.H.

Deputy Director, Imperial Forest School.

The subject matter of this part of the report has been roughly divided into two sections according as the work recorded has been carried out by members (active or retired) of the Forest Department, or by investigators outside the department. This division cannot be absolute, as much work in Forest Botany is done conjointly.

Section I. By far the most important work under preparation during the year has been that by Sir D. Brandis entitled "Indian Trees," of which Part I has already been some time in print and the greater part of Part II is now in the Press. A considerable number of specimens have again been forwarded to Sir D. Brandis from various officers during the year, many of which however have arrived too late to be made use of.

Of new species actually published there have been but few. *Lindera aromatica* Brandis appeared in Hooker's *Icones*¹ and Mr. Bourdillon has published in the *Indian Forester*² plates as well as descriptions of the following trees:—*Dialium travancoricum* Bourd. a magnificent evergreen tree from South Travancore. This tree was provisionally referred to *D. coromandelianum* Houtt. in Gamble's Manual. *Eugenia Rama-Varma* Bourd. from the evergreen forests of Travancore and Tinnevely, and *E. occidentalis* Bourd. a small tree from the same parts.

¹ Hook *Icones* Plant T. 2784. ² *Indian Forester*, Vol. xxx. Nos. 4, 5, 6, 8.

Colonel Beddome in writing his *Flora Sylvatica* some 30 years ago alluded to *Dalbergia sissooides*, Grah. as possibly distinct from *D. latifolia* with which he united it. Colonel Prain¹ united *D. sissooides* with *D. emarginata*, Roxb., a tree of the Andamans but Sir D. Brandis dissents from this view. Mr. Bourdillon² has now given good reasons for maintaining *D. sissooides* Grah. as a distinct species, and has suggested the English name "Malabar black wood" for it.

A note on the Flora of the Jubbulpore Division, Central Provinces, and a list of the trees, shrubs and climbers has been drawn up by Mr. R. S. Hole³ which though admittedly incomplete is of considerable value. Jubbulpore is interesting as being in the area where the Teak and Sal meet. As usual the Director and Curator of the Herbarium, Calcutta Botanic Gardens, have given much assistance in naming doubtful specimens. Mr. Hole has given vernacular names, but unfortunately he does not specify the particular races who use these names. Dates of flowering and fruiting are given where known, as also in a few cases sylvicultural and other useful notes.

Notes on the flora of Northern Ganjam have been compiled by Mr. C. E. C. Fischer⁴. This district is practically the southern limit of Sal, a few only occurring in the Vizagapatam district. Mr. Fischer's notes are not confined only to forest botany however, but include flowering plants generally.

A preliminary list of the plants of the Chittagong Hill Tracts and Collectorate has been prepared by Mr. Heinig,⁵ who is now engaged on its further elaboration.

An incomplete list of the trees and shrubs of the Sub-Himalayan tract of the Champaran district was drawn up by Mr. Haines and printed as an appendix to a report on the Bettiah Raj forests⁶, and a commencement was made in the writing of a Forest Flora of Chota Nagpur.

In September 1904 Mr. Ryan read a paper before the Bombay Nat. Hist. Society⁷ on the water-yielding plants of the Thana forests but this chiefly deals with *Calycopteris floribunda*.

¹ Jour. Asiatic. Soc., lxxx, No. 1, p. 41. ² Indian Forester Vol., xxxi, No. 3. ³ Indian Forester Vol. xxx, Nos. 11, 12. ⁴ Journ. Bombay Nat. Hist. Soc., Vol. xv, No. 4. ⁵ Not yet published. ⁶ Official paper only. ⁷ Journ. Bombay Nat. Hist. Soc., Vol. xvi, No. 1, p. 65.

It is impossible to enumerate here all the hitherto undescribed species of which specimens have been communicated by Forest Officers to various herbaria. Perhaps the most interesting of these were contained in collections sent by Mr. Manson from Tenasserim, one of the trees called kalamet with fragrant wood, which Mr. J. R. Drummond, I.C.S., retired, late of the Punjab Commission, has proposed to name *Mansonia Gagei*. Mr. Osmaston also made considerable additions to the Sikkim Flora. A forest flora of the Sikkim and British Bhotan Hills is very badly required. Such a work had actually been commenced during the year but was put a sudden end to by the transfer of both the officers engaged on it.

Turning to another line of enquiry, the question of root suckers has been engaging considerable attention.¹ Some of the writers contend that the members from which suckers arise are morphologically underground branches, but there is no doubt whatever that most suckers in the case of trees spring from adventitious buds formed in true roots. The main object of the discussion however has been to show the very large number of trees which tend to form suckers, especially under the influence of some stimulus such as the felling of the principal stem or the uncovering or the wounding of superficial roots. Altogether some 94 species of Indian trees distributed among 28 orders are now known to produce suckers. Of these the Leguminosæ furnish 28 species.

Mr. Rama Rao, who has before furnished most valuable notes on the root parasitism of the Sandal, again followed up the subject during the year,² and has discovered evidence of the parasitism on upwards of 70 species of plants. In 1884 Hutchins had noticed that Sandal did not succeed in pure woods, and other Forest Officers (notably Messrs. McCarthy and Lushington) have from time to time given evidence of parasitism, but a scale of species arranged to show the best hosts for the Sandal is still a sylvicultural desideratum. Mr. Rama Rao has indicated the Mimoseae as good nurses, but some of his observations in this direction (*e.g.*, in the case of the Anonaceae) do not quite tally with Mr. Barber's investigations.

¹ *Vide* letters by Messrs. Lushington, Ryan, Hobart Hampden, Stevens and Gleadow in Indian For., Vol. xxx, Nos. 4, 7, 10. Vol. xxxi, No. 3. ² Indian Forester, Vol. xxx, Nos. 6, 8, 9.

Section 2. Forest Botany outside the department.

The hemi-parasitism of *Santalum* has long been suspected. Scott discovered the haustoria as long ago as 1871, Warming and Strasburger have described the whole of the Santalaceae as root parasites, and Schimper refers to *Santalum* as hemi-parasite. Doubts have however sometimes been raised on the point and several systematic works make no reference to its parasitic nature. Mr. Barber has not only finally established the hemi-parasitism, but has fully described and illustrated the anatomy of the haustoria and their connections with the roots of other plants.¹ He also shows that the Sandal exhibits a marked preference for certain hosts, but it does not appear to be nearly so particular in its selection as many other parasites, and the haustoria have been found to attach themselves to the most various objects. Mr. Barber is engaged on the study of the whole family morphologically and oecologically, as well as of other Phanerogamic parasites.

In the June number of the Transactions of the Linnean Society² appeared Dr. Stapf's valuable contribution to the natural history of the bamboos. This deals with the remarkable "berry-bearing" genera *Melocanna*, *Melocalamus* and *Ochlandra*. *Melocanna* has been fully described. The whole structure and development of the ovules and fruit is most unlike that of other Gramineae. The ovules are naked, so that the seeds have no testa, while the endosperm is reduced to a mere film ("diaphragm" of Stapf), the scutellum is enormously developed and the embryo is sharply curved. The large fleshy pericarp becomes filled with starch which, as the embryo and young plant develop, is absorbed by the scutellum. The genus is viviparous.

Contributions to Forest Systematic Botany by botanists outside the department are usually included in works covering a wider field. The Monograph of the genus *Diospyros* in Ceylon by Mr. Herbert Wright is however essentially of forest interest.

In the series of papers entitled *Noviciæ Indicæ*, by Colonel Prain, while new localities are given for a large number of Forest species, one new genus "*Woodburnia*" (*Araliaceæ*)³ is described and descriptions given of the following trees and shrubs,⁴ *viz.*, *Sterculia*

¹ *Indian Forester*, Vol. xxx, No. 12. Vol. xxxi, No. 4. ² *Trans. Linn. Soc.* Vol. vi, Bo. Part 9, p. 401. ³ *Journ. Asiat. Soc. Beng.* lxxiii, Part II, No. 1. ⁴ *Id.* No. 5

Kingii *Prain*, of which complete specimens were sent by Mr. Osmaston, is a not uncommon small tree in Sikkim; *Euonymus macrocarpus*, *Gamble*; *E. kachinensis*, *Prain*; *E. subsulcatus*, *Prain*; *E. Wrayi King*; *E. viburnoides*, *Prain*; *E. Lawsoni*, *Clarke*; *Gymnosporia sikki-mensis*, *Prain*; *G. Curtisii*, *King*; *Crudia Mansoni*, *Prain*; *Humboldtia Bourdillonii*, *Prain*; *Rosa gigantea*, *Collett*; *R. Collettii*, *Crepin*; *Pyrus Kurzii*, *Watt*; *Terminalia burmanica*, *King*; *Woodburnia penduliflora*, *Prain*; *Musa Nagensium*, *Prain*. Colonel Prain has also revised the species of *Celastrus* as diagnosed in the Flora of British India, and in doing so described three new species.¹ He also continued his descriptions of the Asiatic species of *Ormosia*.² The family of Dioscoreaceæ are important in forest botany from their being so often used as food by jungle tribes, while some are extensive climbers. Hitherto published accounts of the species have been inadequate for their determination. They have recently been very thoroughly studied both wild and in cultivation by Prain and Burkill, and in addition to several new species from China and Japan, three new species have been recorded from Burma and one from Sikkim.³ De Candolle argued a recent cultivation of the yams in India, but *D. alata* is now cultivated all over India, Ceylon and Burma as well as China, and according to De Candolle, also the Pacific Islands: but, he added, "no one pretends to have found this species in a wild state." It is a most interesting discovery of Mr. Burkill's, therefore, that this species is wild all over the Northern Shan States, and he has probably discovered the original home of this important plant.

During little less than a month's tour in the Minbu district of Upper Burma Captain Gage has added a new locality to between 40 and 50 woody plants, and has described new species of the following genera:—*Boscia* (Capparideæ) *Bombax* (probably new, though previously included in *B. insignis* by Kurz), *Vitis*, *Indigofera*, *Derris*, *Argyreia*, and *Lettsomia*, (the last two scandent and scarcely woody). A list of the plants is accompanied by a general description of the topography and vegetation with a discussion of its affinities and distribution.

Uniform with Colonel Prain's eminently useful and interesting Flora of the Sunderbans, we now have a Flora of the districts of

¹ Journ. Asiat. Soc. Beng. lxxiii, Part II, No. 5. ² Id. No. 2. ³ Id. No. 4.

Hughli-Howrah and the 24-Pergunnahs. Important as this is botanically, "as there is not a forest, and scarcely perhaps an indigenous forest tree" in the whole area, excepting that portion forming part of the western Sunderbans and, as this is necessarily included in the author's previous work, the book is of only indirect interest from the standpoint of Forest Botany.

The "Botanical Regions" of South India have been fully described by Mr. Barber in an article on Botany to the Imperial Gazetteer, while notes on the Flora of South Arcot and Godaverri have been contributed to the District Manuals. Other Forest districts have also been under special study with the assistance of the Forest Department, the results of which are not yet published.

In the province of cryptogamic botany Mr. Butler has investigated several diseases of trees during the year. Among these a disease of *Pinus excelsa* has been found to be due to the well known European fungus parasite *Trametes Pini*, which attacks Pines, Firs, Spruce and Larch. In one forest in the Simla division half the trees are reported to be attacked and the timber rendered useless from the "spongy red-rot of the heart wood" which results. The treatment must lie in "preventing the hacking of branches and the removal of infected trees."

The "Witch's Broom" of the deodar, common in Jaunsar, is found to be due to *Peridermium Cedri*, a fungus, so far as is known, peculiar to the Himalaya. The *Casuarina* root disease which is prevalent in some plantations on the East Coast is produced by a fungus of the genus *Trichosporium*, which invades the roots and collars of the trees and kills them off in centrifugally expanding patches. An account of the disease by Mr. Butler will shortly appear in the "Indian Forester." Root-rot of a number of trees, including *Schleichera*, *Holigarna longifolia*, *Grevillea*, species of *Litsea*, &c., in the Mysore Ghât tracts has been ascertained to be the result of *Rosellinia bunodes*, a fungus probably arising, like other destructive *Roselliniæ*, in decaying wood.

Attempts to produce the "spike" disease of Sandal by artificial inoculation have failed, and no further light has been obtained regarding its cause. An interesting photograph of the effects of this disease on the Sandal was communicated by Mr. Lushington to the "Indian Forester" in the January 1905 number.

FOREST PRODUCTS.

BY

M. HILL, F.L.S.

Assistant Inspector-General of Forests to the Government of India.

In collaboration with the Reporter on Economic Products to the Government of India, a large amount of work was done during the year in connection with the collection, investigation and analysis of Forest products, including gums, resins, rubber, oils, dyes, tans, fibres, timbers, &c.

Gums.—Gums of numerous species of forest trees and climbers were collected with the object of determining the properties of Indian gums and ascertaining which are suitable for export.

The gum obtained from the Dhaura tree (*Anogeissus latifolia*) yielded a colourless solution, highly viscid and adhesive. It is considered very suitable for export.

The gum obtained from *Pithecolobium lobatum*, a tree growing in Hanthawaddy, Burma, formed a dark coloured solution with water which readily fermented. It was therefore of little value.

Resins.—Resins of several species, including *Dipterocarpus tuberculatus*, *Pentace burmanica*, *Hopea odorata*, *Mesua ferrea*, &c., were obtained from Burma and Assam. The resin of *Hopea odorata* has formed the subject of report by Professor Dunstan (Commercial circular No. 1 of 1904) and that of *Altingia excelsa* has been described in Agricultural Ledger No. 9 of 1904.

Oils.—The enquiry into Indian oils inaugurated by Sir Frederick Abel is making fair progress. During the year oils of *Amoora Rohituka* and *Calophyllum tomentosum* were collected and sent to the Reporter on Economic Products, who forwarded them to the Imperial Institute. Seeds of *Croton oblongifolius* were collected in Bengal for analysis.

A report on the seeds of *Schleichera trijuga* as a source of Macassar oil was issued in Agricultural Ledger No. 1 of 1905.

Tannins.—Pods of *Caesalpinia digyna* from Burma were distributed to various tanneries for experiment and report. The roots of *Rumex*

hastatus and *Polygonum nepalense* were analysed to determine their strength in tannic acid: the former yielded from the dried roots the following amounts of extractive matter and tannin:—Aqueous extract 18.2, tannin 11.6, and the latter 29.9 aqueous extract and 15.9 tannin.

Preliminary investigations into the possibility of utilizing the barks of *Shorea robusta* and *Terminalia tomentosa* as tanning materials were made by the Director, Imperial Institute, London, and the results obtained so far tend to show that it is likely that the extracts obtained from these species will, when employed as tanning materials, furnish leathers of good texture and colour. Arrangements have been made for the preparation of extracts from these barks at the Government tannin extract factory, Rangoon. The extracts will be forwarded to the Imperial Institute for chemical examination and commercial valuation.

The bark of *Artocarpus Lakoocha*, which is frequently used for tanning in Assam, was examined and found to contain 8.5 per cent. of tannic acid.

Turpentine oil and resin from the United Provinces have been sent to the Imperial Institute for chemical and commercial valuation.

Considerable quantities of turpentine and colophony are now manufactured in the United Provinces. During the year 62,000 pine trees were tapped, yielding an average of 2.7 seers of crude resin a tree. Each maund of crude resin yielded 1.4 gallons of turpentine and 25.6 seers of colophony.

Rubber.—A large number of samples of crude rubber of various species were collected from different provinces, and analysed by the agricultural chemist to the Government of India.

Samples of rubber from Assam and Burma were sent to the Imperial Institute, London. A report was made on the yield of rubber from the dried bark and leaves of *Ficus elastica*, from which it appears that it is very doubtful whether the yield and quality of the rubber even from fresh bark or leaves would be sufficient to justify attempts to extract it upon a commercial scale.

Samples of crude rubber obtained from the following species yielded upwards of 50% of caoutchouc:—

Rhynchosia Wallichii 86.5 %—This specimen was obtained from Tennasserim, Lower Burma, and examined at the Imperial Institute, London. The physical properties of the rubber were found to be very satisfactory: it was valued at 3s. 6d. a lb, the rate for Para rubber at the same time being 4s. 8d. a lb.

Ecdysanthera micrantha 84 %—This plant, known in Burma as "Nwede," is a climber and has only been definitely recognized as a source of rubber during the last two or three years. It is stated to occur in Assam, Burma, Siam, Southern China and French Indo-China, and in the last named country it is exploited by the natives for its rubber.

The rubber was reported by Professor Wyndham R. Dunstan to be of good quality though the percentage of resin (11.5) found was higher than desirable.

Two samples of crude rubber obtained from a climber (*Anodendron* sp.?) in the Kengtung forests, Southern Shan States, yielded 94.6 per cent. caoutchouc. The rubber was most favourably reported on and valued at about 4s. a lb.

A sample of crude rubber of *Ficus elastica* from Upper Burma yielded 82.6 per cent. caoutchouc. And crude rubber of *Cryptostegia grandiflora* from Bombay yielded 83.4 per cent., while a variety of other samples, principally *Ficus* sp. yielded from 3.9 per cent. to 50 per cent. caoutchouc. The majority of the analyses were made by Dr. Leather, Agricultural Chemist to the Government of India.

Yams.—A number of yams—*Dioscorea* sp.—were collected from different provinces and will form the subject of an important enquiry jointly undertaken by Mr. Burkill and Colonel Prain.

Canes.—A number of canes from Burma, Madras, etc., were collected. Some of these are of great botanic interest, a specimen from South Coimbatore having proved to be *Calamus Rheedei*, a species hitherto only known from Rheede's figure. At the suggestion of Sir Dietrich Brandis, duplicates of the botanical specimens are being submitted to Dr. Beccari, of Florence, for his opinion.

Fibres.—A variety of plantain fibres was collected from different provinces, and these will be described in connection with the botanical

origin of the plants, and their comparative breaking weights will be recorded.

The fruits, roots, leaves, etc., of poisonous *Daturas* were collected in connection with the investigation to determine the amount and nature of the alkaloid present in these plants. The chemical constituents of the seeds of *Gynocardia odorata*, *Taraktogenos Kurzii* and *Hydnocarpus Wightiana* collected in Assam, Madras, etc., were reported on by Dr. F. B. Power.

Timbers.—A very large number of timbers of various species were collected from different provinces and supplied to the Reporter on Economic Products, the Director, Botanical Survey of India, the Principal, Civil Engineering College, Sibpur, and Museums and Institutions in India and America.

Wood pulp.—As a result of enquiries regarding the feasibility of utilizing in the form of wood and bamboo pulp, the large quantities of inferior species of trees and of bamboos contained in the forests of India, which at present possess little or no commercial value, the services of a competent expert has been arranged for, with the object of thoroughly investigating on the spot the conditions on which it would be possible to start the industry.

Botanical Specimens.—Numerous botanical specimens were collected in most provinces and sent to the Royal Botanic Gardens, Calcutta and Kew, and to the Reporter on Economic Products, India, and to the latter were also sent, from the Bombay Presidency, a collection of fruits, roots and seeds likely to be suitable as famine foods.

Seeds.—A quantity of seeds of the more important Indian species, including *Cedrus Deodara*, *Pinus longifolia*, *Cupressus torulosa*, *Dalbergia Sissoo*, *Shorea robusta*, *Tectona grandis*, etc., etc., and a variety of bamboos were collected and despatched to British Colonies and Foreign Governments and Institutions.

General.—286 Samples of various products were tested and examined in the laboratory of the Industrial Section, Indian Museum, under the superintendence of Mr. D. Hooper, F.L.S. Among the food stuffs examined, the following three are of interest. Fruits of *Cactus* (*Opuntia Dillenii* from Nellore), roots of *Aponogeton monostachyun*

from North Salem. The Dodder plant (*Cuscuta reflexa*) :—

	Opuntia.	Aponogeton.	Cuscuta.
Water	5'67	7'50	6'75
Fat	3'63	'76	1'90
Albuminoids	6'25	9'18	9'62
Carbohydrates	41'89	71'00	65'68
Fibre	32'00	3'50	10'10
Ash	10'56	8'06	5'95
	<u>100'00</u>	<u>100'00</u>	<u>100'00</u>

Some seeds of *Pithecolobium lobatum* were sent from Tennasserim for a report on their value as a food-stuff. On analysis they were found to contain some 69 per cent. of carbohydrates and 17 per cent. of Albuminoids, with small quantities of fat, fibre and water.

Pine needles of the chil pine (*Pinus longifolia*) were examined to ascertain their value in oil or other commercial product contained in them, with the result that it was found that neither essential oil, resin nor tannin was in sufficient large proportion to pay for its extraction. Among other products, not already referred to, which formed the subject of investigation may be mentioned "Pwenyet," the product of the *Melipona laeviceps* or Dammar Bee of Burma; a whitish resin from the Hollong tree (*Dipterocarpus pilosus*); a green resin of *Calophyllum inophyllum*, characterised by its solubility in alcohol, its high acid value and its coumarin-like aroma. A number of samples of Cutch were tested to ascertain the amount of tannin, soluble non-tannins, insoluble matter and ash. The percentage of tannin in good samples varied from 40 to 70. The Burmese Cutch was found to be uniformly good. Specimens of adulterated Cutch were rare.

Burmese Storax, oil-seed of *Dichopsis ovata*, fruits of *Olea cuspidata* (the Indian olive), fibres of Sabai grass from Nepal Terai, of the climber *Bauhinia Vahlia*, of wild cardamom of Assam (*Alpinia Allughas*) and of sunflower (*Helianthus annuus*) and various medicinal products also formed the subject of study and investigation during the year.

List of books and papers bearing on Forestry, Forest products, etc., in India received or issued during 1904-05.

1. Flora of the Upper Gangetic Plain and of the Adjacent Siwalik and Sub-Himalayan Tracts, Vol. I, Part II by J. F. Duthie, B.A., F.L.S.
2. Schlich's Manual of Forestry, Vol. III, Forest Management, 3rd Edition by W. Schlich, P.L.D., C.I.E., F.R.S., F.L.S.
3. Note upon the "Bee-hole" Borer of Teak in Burma by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
4. Note on the Quetta borer by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
5. Note on the Chilgoza bark boring insects of Zhob and Baluchistan by E. P. Stebbing, F.L.S., F.Z.S., F.E.S.
6. The Cultivation and preparation of Para Rubber by W. H. Johnson.
7. Firminger's Manual of Gardening by J. Cameron, F.L.S.
8. Review of Forest Administration in British India for the year 1902-03 by S. Eardley-Wilmot, Inspector-General of Forests, Govt. of India.
9. A paper on the gums of various species of Acacia. (Indian Forester, September 1904) by D. Hooper, F.C.S., F.L.S.
10. *Altingia excelsa* (Burmese Storax) Agricultural Ledger No. 9 of 1904 by D. Hooper, F.C.S., F.L.S.

THE PROGRESS OF ZOOLOGY IN INDIA DURING THE
YEAR 1905.

BY

LIEUT.-COL. A. W. ALCOCK, I.M.S., C.I.E., M.B., C.M.Z.S., F.R.S.
Superintendent of the Indian Museum.

This is a brief review of the principal work in Indian zoology published between the 1st December 1904 and the 30th September 1905. It deals with zoology in the ordinary, restricted, sense of the term: it does not include certain memoirs that have appeared in the Royal Society's *Proceedings* and *Transactions*, and in the "Scientific Memoirs," on the physiological properties of snake-venom; or the papers, of purely pathological interest, that have been published in the "Scientific Memoirs" and in the *Quarterly Journal of Microscopical Science*, on certain Protozoan blood-parasites of man: nor does it embrace the subject of Economic Entomology, which is dealt with by a separate agency.

In the period under report I have found 80 series of papers (not separating the multifarious Notes and Queries contributed by sportsmen and enthusiastic members of the Bombay Natural History Society to the "Miscellaneous" Appendices of their *Journal*) dealing either exclusively or in major part with the Indian fauna: of these no less than 55 are the work of zoologists living in Europe, and only 25 have been contributed by India. This is a strange record for a country where Universities and their affiliated colleges are now quite numerous and the choicest material for zoological research is to be found almost at the door of every student; and it shows that in India, far more even than in other parts of the British Empire, the value of the study of zoology—even in its practical applications to human safety and comfort, and to some of the most important, if simplest, of human industries—is still unrealized by the educated classes.

1. **Comprehensive Official Publications.**—Under this head may be mentioned the first volume of the *Butterflies of India* by Colonel C. T. Bingham, published by His Majesty's Secretary of State for India; the

eleventh fascicle of the Illustrations of the Zoology of the "Investigator," published by the Director of the Royal Indian Marine; and the Report on the "Investigator" Holothurioidea by Messrs. R. Koehler and C. Vaney, and the Catalogue of the Indian Paguridæ by Major A. Alcock, published by the Trustees of the Indian Museum.

2. **Unofficial Monographs** include 5 parts of Mr. F. Moore's Lepidoptera Indica; the important Monograph of the *Anopheles* Mosquitoes of India, by Captains S. P. James and W. G. Liston; and an instalment of Mr. Stanley Gardiner's Fauna and Geography of the Maldiva and Laccadive Archipelagoes, dealing with Cephalopods, parasitic worms, and several groups of Coelenterates, Crustaceans, and Insects. Here too may be mentioned, as being within our scope, though outside our official reckoning, the second and third parts of Dr. W. A. Herdman's Report on the Pearl Oyster Fisheries and Marine Biology of Ceylon; and several Reports of the German Deep Sea ("Valdivia") Expedition which, in its course, crossed the Arabian Sea and the Bay of Bengal.

3. Short Papers and Serials.

1. **Mammals.**—The *Journal* of the Bombay Natural History Society contains a paper by Colonel A. E. Ward on the small mammals of Kashmir, and one by Mr. R. C. Wroughton on the common striped Palm-squirrel. In the *Annals and Magazine of Natural History* a new vole from Kashmir is described by Mr. J. L. Bonhote, and a new squirrel from Burma by Mr. Oldfield Thomas, F.R.S. Mr. R. Lydekker, F.R.S., has contributed notes on the Gorals of India and Burma to the *Zoologist*, and a paper on Dolphins from Travancore to the *Proceedings of the Zoological Society*. Finally in the *Zoologischer Anzeiger* Dr. Hiltzheimer publishes some critical notes on the tiger-skulls in the Strassburg Museum.

2. **Birds.**—In the *Journal* of the Bombay Natural History Society the avifauna of Darbhanga by Mr. C. M. Inglis, and that of Travancore by Mr. H. S. Ferguson, are continued; Captain H. T. Fulton publishes notes on the Birds of Chitral, and Mr. D. Dewar on those of Madras; and Mr. E. W. Oates describes some new species of Silver Pheasants from Burma. Three new species of birds from Tibet are described by Mr. H. E. Dresser in the *Proceedings of the Zoo-*

logical Society; and in the *Indian Forester* Mr. F. Finn concludes his account of the Indian Pheasants.

3. **Reptiles and Amphibia.**—Dr. N. Annandale has published several papers in the *Journal* of the Asiatic Society of Bengal under the titles "Contributions to Oriental Herpetology" and "Additions to the Collection of Oriental Snakes in the Indian Museum," and has also contributed Notes on some Oriental Geckos to the *Annals and Magazine of Natural History*, and Descriptions of abnormal Ranid larvæ from North East India to the *Proceedings* of the Zoological Society. In the *Journal* of the Bombay Natural History Society there are to be found descriptions of three new species of snakes from Upper Burma, in papers by Mr. G. A. Boulenger, F.R.S., and by Captain F. Wall, and copious notes by the latter author on the snakes of Cannanore and Bangalore. Mr. Boulenger also describes, in the *Annals and Magazine of Natural History*, some reptiles and batrachians from Tibet. In the *Proceedings* of the Zoological Society Mr. F. E. Beddard, F.R.S., discusses the visceral anatomy of the sea-snakes *Hydrus* and *Platurus*. Finally, the *Zoologischer Anzeiger* contains an important paper by Dr. Roux, entitled "La Famille des Ranidæ," in which the Indian genera established since the publication of the volume on Reptiles and Amphibia in the Fauna of British India are tabulated.

4. **Fishes.**—Some new Cyprinoid Fishes from Tibet form the subject of two papers in the *Annals and Magazine of Natural History* by Mr. C. T. Regan, and the same author gives an account of the Fishes of the Persian Gulf in the *Journal* of the Bombay Natural History Society. A new genus of Teleostean fishes allied to *Chiasmodon* is also described by Captain MacGilchrist in the *Annals*. Mention must here be made of Dr. W. G. Ridewood's important papers on the cranial osteology of the *Notopteridæ*, published in the *Journal* of the Linnean Society, and on that of the Clupeoid Fishes published in the *Proceedings* of the Zoological Society, although they go beyond the Indian fauna in their reach. It is convenient, too, to notice here a paper by Mr. G. H. Parker in the *Bulletin* of the Museum of Comparative Zoology of Harvard, on the Maldivé *Cephalochorda*.

On the whole, as the four preceding paragraphs show, our knowledge of Indian Vertebrates has not been much increased during the last 10 months, and workers, with few exceptions, have kept to the beaten track. Nor is it easy to see how any great progress can be made, locally, until the educated classes of the country begin to show an interest in comparative anatomy and embryology, and in that experimental biology which in Europe already promises to discover something of the laws of heredity, and so to throw further light upon the origin of species and the production of useful breeds, and to point out rational paths to would-be reformers of the human race.

5. **Mollusca.**—The record consists of two papers: one by the late Dr. W. T. Blanford F. R. S., on Indian and Burmese Land-shells, published in the *Proceedings* of the Zoological Society; the other by Mons. A. Bavay, entitled "Espèces Nouvelles du Genre *Pecten* provenant de L'Indian Museum," published in the *Memoirs* of the Zoological Society of France. The account of the *Cephalopoda* in Mr. Stanley Gardener's Monograph, and Dr. Herdman's Reports on the Pearl Oyster have already been referred to.

6. **Insecta.**—Excluding the special subject of Economic Entomology, and the three monographs before mentioned, I find 28 sets of of papers recorded, a minority of which are to be credited to workers now resident in India. The Earwigs of the Indian Museum Collection are described by Mr. M. Burr in the *Journal* of the Asiatic Society of Bengal. In the *Journal* of the Bombay Natural History Society Sir George Hampson's supplement to the Moths of India, Mr. G. C. Dudgeon's descriptions of Indian and Burmese Moths, and Major G. C. Nurse's descriptions of Indian Hymenoptera, are continued; while Mr. E. H. Meyrick, F.R.S., contributes a paper on Indian Microlepidoptera, and Mr. E. C. H. Young, one upon Bombay Orthoptera. The Royal Society's *Proceedings* contain a note by Majors Adie and Alcock on the occurrence of *Anopheles Listoni* in Calcutta. Colonel J. M. Fawcett, in the *Proceedings* of the Zoological Society, writes briefly on Butterflies of the N. E. Himalayas. In the *Transactions* of the Entomological Society there are papers by Dr. N. Annandale on the egg, the early larval stages, and the Hymenopterous parasite of a Coreid bug, and by Mr. G. B. Longstaff on the Butterflies observed

during a tour in India and Ceylon. Entomological contributions to the *Annals and Magazine of Natural History*, include descriptions of Oriental Aphodiid Coleoptera, by Mr. G. J. Arrow; of new Sphegid and Ceropalid Hymenoptera, by Mr. P. Cameron; and of new Eastern Heterocera in the British Museum, by Colonel C. Swinhoe. In the *Proceedings* of the United States National Museum for 1904 a paper by Mr. E. B. Williamson, on the Dragonflies of Burma (and Lower Siam), must be noticed. Two papers by Mr. C. Ritsema, in the *Notes* of the Leyden Museum, upon the species of the Coleopterous genus *Helota*, refer more or less to India. In the *Bulletin* of the Paris Natural History Museum Dr. Max Hagedorn enumerates the Scolytid beetles of Sikkim (and Japan), and Dr. Joanny Martin describes a new genus of the *Natalicolaria* group of Hemiptera from India. The *Revue d'Entomologie* for 1904-05 contains several papers of importance to India, namely upon exotic Staphylinid beetles, by Mons. A. Fauvel, and upon the Enoplotrupes and Geotrupes beetles of Asia by Mons. A. Boucomont. To the *Annales* of the Belgian Entomological Society for 1904-05 Mr. Martin Jacoby contributes a long account of Indian Phytophagous Coleoptera; Mons. J. Bourgeois' descriptions of 4 new species of *Lycides* (Coleoptera) from Bengal; and Mons. A. Forel, under the heading *Miscellanea Myrmecologiques*, a short account of the ants of the Nicobars. Finally, in the *Biologisches Centralblatt* for 1905, Dr. F. Doflein publishes some observations on the leaf-nesting ant, *Oecophylla smaragdina*.

7. **Arachnida and Crustacea.**—Dr. Karl Kraepelin's Geographische Verbreitung der Scorpione, published in the *Zoologischer Anzeiger* for 1905 is of great importance to the student of the Indian fauna. In the *Journal* of the Asiatic Society of Bengal Mr. E. Vredenberg notes the occurrence of *Apus* in Baluchistan. In the Smithsonian Miscellaneous Collection Quarterly Issue 1905, Mr. N. S. Jambunathan gives an account of the habits and Life History of a Social Spider (*Stegodyphus sarasinorum* Koch). To the *Annals and Magazine of Natural History* Captain A. C. MacGilchrist contributes an account of new and rare Decapod Crustacea dredged by the R. I. M. S. "Investigator," and Major A. Alcock a description of a new species of the Dorippoid genus *Cymonomus*, and a discussion of the distribution of the

Dorippida and its possible bearing upon a problem of past geography.

8. **Vermes.**—Dr. Annandale, in the *Journal* of the Asiatic Society of Bengal, has described a new species of *Chætogaster* commensal with a pond-snail. In the *Bolletino* of the Zoological Museum of the University of Turin for 1904 Signor Camerano gives an account of a new species of Gordiid from Upper Burma, and in the Systematic part of the *Zoologische Jahrbucher* for 1905, Dr. Klein has a paper on the parasitic flukes of one of the common Indian frogs (*Rana hexadactyla*).

9. **Cœlenterata.**—Dr. Annandale, in the *Journal* of the Asiatic Society of Bengal, has a short note on the Hydra found in the Calcutta tanks. In the *Annals and Magazine of Natural History* Professor Arthur Thomson and Dr. Henderson publish a preliminary notice of the Deep-Sea Alcyonaria dredged by the R. I. M. S. "Investigator;" while another Zoologist of the Aberdeen University, Dr. J. J. Simpson, contributes to the *Zoologischer Anzeiger* a full description of a new type of Siphonogorgid Alcyonarian from the "Investigator" collections.

10. **Protozoa.**—Besides some papers of purely pathological interest, the "Scientific Memoirs" contain an account of a parasite found in the white corpuscles of the blood of dogs, by Captain S. P. James, I.M.S., and a study of *Hamogregarina gerbilli*, by Lieut. S. R. Christophers I.M.S.

11. **Miscellaneous.**—Here may be mentioned an interesting and suggestive paper by Captain W. G. Liston, I.M.S., upon the connection between plague, rats, and fleas, which appears in the *Journal* of the Bombay Natural History Society.

The Natural History Section of the Indian Museum.—The institution has been enriched (1) by the purchase of a large and well-arranged collection of Moths, brought together during 20 years' residence in India by Mr. G. C. Dudgeon; (2) by a further consignment of rare material collected by the R. I. M. S. "Investigator;" (3) by numerous specimens of the fauna of Seistan and its vicinity, collected by the officers of the Seistan Arbitration Commission under Col. A. H. McMahon, C.S.I., C.I.E.; and (4) by a very select and well-preserved lot of material—including a fine male dugong—from the Madura

District, collected by Dr. N. Annandale while on special deputation for the purpose. Also, thanks to the friendly co-operation of European naturalists, much progress has been made in the work of systematizing the collections, and numerous groups—including small Mammals, Mollusca, Insects, Entomostracous Crustacea, Echinoderms, Coelenterates, and Planarians—have been entrusted to experts in England and on the Continent to be named and described. The Museum has also continued to co-operate with the kindred institutions of Europe in freely exchanging desiderata.

The publications of the Museum have already been mentioned, and several others are in progress, of which the most important are the following:—(1) a report, by Professor Arthur Thomson and his assistant Dr. Henderson, on the "Investigator" Alcyonarians; (2) a report, by Messrs. R. Koehler and C. Vaney, on the "Investigator" Echinoids; (3) a report, by Mr. E. A. Smith, I.S.O., on some "Investigator" Deep-Sea Mollusca; (4) a report, under the superintendence of Professor L. Joubin, on the Oriental species of *Arca* in the Indian Museum; and (5) another instalment of the Catalogue of Decapod Crustacea by Lt.-Colonel A. Alcock.

Reviewed as a whole, the present condition of Zoological Science in India, depending so much as it does upon spasmodic amateur effort at home and upon casual expert assistance from abroad, is very far from satisfactory. The essential requisites to further progress are:—

- (1) An organized zoological survey, chiefly directed towards collecting and observing those forms of invertebrate life—prodigious in number and fertile in every kind of interest—which are neglected by the amateur.
- (2) A considerable increase of the trained staff of central museums of reference like the Indian Museum.
- (3) The establishment of zoological laboratories and small teaching museums in all the large university-colleges of northern and western India, with professors in charge whose sole duty should be to teach, and to conduct research.

Until something of this kind is done, zoology in this country can hardly be anything more than a pastime of a few peculiar spirits, as it was in Europe about 100 years ago.

AGRICULTURAL ENTOMOLOGY.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.

Entomologist to the Government of India.

Study of Insect Pests of Crops.—The study of the insect pests of Indian crops has been continued by Mr. H. M. Lefroy, M.A., F.E.S., F.Z.S., Government Entomologist, and by provincial assistants under his control. The common pests of the more important crops have been investigated and their classification and life-histories worked out, more particularly those of Behar, where the head-quarters of the Government Entomologist are located at the Pusa Research Institute. The more important results have been published in a series of leaflets, dealing with some injurious insects and practical remedies against their attacks. A special inquiry was concluded into the Insect Pests of Coffee.

The Bombay Locust.—(*Acridium succintum*). A severe plague of Bombay Locusts in 1904, which caused great damage, led to a special investigation of this pest by Mr. Lefroy in conjunction with the Bombay Department of Agriculture. The full life-history of this locust was investigated for the first time, and measures for its destruction were devised and carried out on a large scale. A report giving a complete account of this inquiry will shortly be published.

Tea Pests.—An investigation of the most serious insect pest of tea, known as mosquito blight and caused by a plant bug (*Helopeltis theivora*) has been made by Dr. H. H. Mann, D.Sc., Scientific officer of the Indian Tea Association, with the result that a method of cure has been devised, which has been successful under suitable conditions. Dr. Mann has published two bulletins on "The Mosquito Blight of Tea", and a third is now in the press.

Sericulture.—The Bengal Silk Committee, who are assisted by a Government subsidy, have continued their efforts to induce the mulberry silk rearers to use only healthy seed examined by the microscope under the Pasteur system, a special establishment being employed at silk rearing depôts, where classes are held. This work is reported to have achieved some results, rearers

now appreciating the necessity for healthy seed and the use of the microscope. Some experiments have been made in Assam with imported French and Italian seed with successful preliminary results. Seed was distributed to some rearers, who obtained good returns. Examination revealed the existence of *pebrine* and *flacherie* in the moths, so that reliance must be placed upon imported seed until local arrangements are made for rearing healthy seed. A special inquiry was made into the indigenous tasar silk industry of Bengal and the Central Provinces by Mr. N. G. Mukerji, M. A., M.R.A.C., F.H.A.S. The decaying state of the industry was found to be mainly due to the prevalence of the *grasserie* disease, which has become widespread since the rearers have taken to using home-bred seed instead of collecting wild cocoons from the forest. (Report on the inquiry into the state of the Tasar Silk Industry in Bengal and the Central Provinces of India.) Some important work has been accomplished at Mr. Tata's private Silk Farm, Bangalore, under the charge of a Japanese expert, who is testing the adaptability to India of Japanese methods of mulberry cultivation, silk worm rearing and silk reeling. The Government of India have sanctioned the establishment of a similar silk farm at the Pusa Institute.

Systematic Entomology.—Progress has been made with the Insect Survey of India, carried on in co-operation with the Indian Museum, Calcutta. Collections were made, classified and sent to Specialists for identification. The result of their investigations are being published in the United States and Europe.

FOREST ENTOMOLOGY.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

Forest Entomologist to the Government of India.

(1) The work of the Forest Entomologist, whilst on furlough, was carried on at the Natural History Museum in London and from thence an official visit was paid to some of the chief Forest Colleges and Museums on the Continent. At the same time work was continued in

connection with the Volume on the *Buprestidæ* for the "Fauna of British India." At the Natural History Museum identification work in connection with the collections already made, as well as of specimens received from India, was carried on, while during April and June the Forest Colleges at Eberswalde, Tharandt, Aschaffenberg, Munich, St. Petersburg, Vienna and Nancy were visited, as well as the Natural history Museums of Brussels, Berlin, St. Petersburg, Dresden, Munich, Vienna, Genoa and Paris.

2. The Chief Economic results of the year are given below :—

(a) By the Forest Entomologist the life history of an undescribed species of *Sphærotrypes*, a Scolytid bark borer of very considerable economic importance in the Sal areas of the Siwaliks, was nearly completed by observations carried out in the autumn.

The controversy regarding the period of ripening of the cones of *Pinus longifolia* was brought to an end by the discovery that some of the so-called cones were galls made by the grubs of a Cecidomyid fly.

A tour in Burma resulted in the discovery of the insect which produces the so called "bee holes" in teak timber. It proved to be the larva of the moth *Duomitus ceramicus*. "Bee hole" teak timber has been the cause of complaints from the British Admiralty and Timber Merchants at Home from the earliest days of teak export work at Moulmein (1820).

Further investigations were made into the life-histories of the teak defoliators *Hyblæa puera* and *Pyrausta machæralis*, and also into the habits of a number of Scolytidæ and various predaceous and parasitic insects, mostly new to science.

A series of experiments were conducted at the Indian Museum (during 1905) with the object of discovering a preservative against the attacks of the bamboo beetles or shot borers (*Dinoderus*). Soaking first in water, then in Rangoon oil, was found to be effective even after lengthy trial on field service as telegraph posts.

(b) By other departmental investigators. Other officers of the Department carried out important investigations. Mr. S. Carr, F. C. H., continued his observations on the life-history of *Hyblæa puera* in the Rangoon Teak Plantations and succeeded in discovering where the

eggs are laid by the moth and how and where the young larvae spend their first stages.

In Madras the serious attack of the larvæ of *Arbela tetraonis*, the Casuarina bark eating insect, which commenced in 1903, was only brought to an end by modifying the provisions of the working plan for some of the Ganjam plantations and cutting out the greater number of the trees. Mr. Latham reported this pest from South Canara on the west coast.

Mr. P. M. Lushington reported several injurious insects of *Swietenia Mahogani* at Nilumbar.

Investigations were also conducted in the United Provinces on the habits of defoliating pests of the Sal, Haldu (*Adina cordifolia*), *Careya arborea*, *Wrightia tomentosa* and *Cassia Fistula*. These are still proceeding, as also are others into teak-leaf galls and insects infesting the seed in Bombay forests, Cynipid and lepidopterous pests in the fruit of *Terminlia Chebula* in Berar and Sal wood borers and leaf defoliators in Assam.

(c) By other observers. As usual important investigations were carried out by non-departmental observers. The Political Agent, Zhob, reported in 1903 that the Chilgoza (*Pinus Gerardiana*) trees in the Shinghar forests were dying off under what appeared to be attacks of insects. From the descriptions received the insects appeared to be Scolytidæ, and the subsequent receipt of a section of a stem with the bark on confirmed this diagnosis. It was arranged that Shinghar should be visited shortly after the close of the year under report in order to prescribe preventive measures against this attack.

Reports were also received that the avenue trees in Quetta were suffering severely from the attacks of insect pests, and during the year under report it was discovered that this insect was a longicorn beetle. The Agent to the Governor-General called for a report on this pest, and a note was prepared by the Superintendent of Arboriculture. The importance of this subject justified a more careful investigation on the spot, the result of which is embodied in a note published after the close of the year.

As in former years the Reporter on Economic Products to the Government of India assisted in this study and forwarded specimens

of four different kinds of beetles found in tunnels in the wood of *Poinciana elata*. Two were wood boring insects, the others predaceous upon them and their grubs.

In accordance with suggestions made when considering the life history of *Pyrausta machæralis* Mr. Bourdillon, Conservator of Forests, Travancore State, submitted valuable quarterly reports on the dates of appearance, amount of defoliation done by, etc., the defoliating insects *Hyblæa puera* and *Pyrausta machæralis*.

3. The chief Scientific Results of the year's work are set forth below.

The discovery of the insect forming the celebrated "bee holes" in Teak in Burma is as interesting scientifically as economically, since *Duomitus ceramicus* had never been previously reported from Burma in spite of its evident great abundance in some localities.

The Cecidomyid gall producer of the *Pinus longifolia* must also be considered an investigation of considerable interest, as both the Cecidomyid and the Chalcid, *Trigonomerus* sp., parasitic upon it are new to science. The beetles mentioned as boring into Poinciana proved to be *Heterobostrychus æqualis* and *Dinoderous punctatissimus*, this being the first information received as to the food of the latter.

Amongst purely literary work the preparation of the Buprestid Volume, in which new Indian species are described, and descriptions of new species of Scolytidæ (*Sphærotrypes*, *Cryphalus*, *Grossotarsus* and *Diapus*) in No. 3 of Departmental Notes may be mentioned. Of this family a special study is being made, as there are but few specialists in the group and practically none to work out the Indian species.

Valuable help in the identification of insects was received from Sir George Hampson and Messrs. Waterhouse, Gahan and Arrow of the British Museum Staff, from Colonel C. T. Bingham, Messrs. G. Lewis, Distant and Dudgeon, from M. P. Lesne of the Paris Museum and Dr. L. O. Howard, Chief of the Entomological Bureau, and Dr. W. H. Ashmead of the Museum, Washington. A list of publications is appended.

Publications.

(1) Casuarina bark-eating Caterpillar (*Arbela tetraonis*) by Mr. C. E. C. Fischer, *Indian Forester*, Scientific papers, xxxi, pp. 9-18 (1905).

(2) Insects pests of Swietenia Mahogani, by Mr. P. M. Lushington *Indian Forester*, Scientific Papers, xxxi, pp. 74-75 (1905).

(3) A volume on Indian Cerambycidae for the "Fauna of British India" by Mr. C. J. Gahan of the British Museum. (*Under preparation*).

(4) On the life-history and habits of the moth *Duomitus leuconotus* in Calcutta by Mr. E. P. Stebbing, *Journal Asiatic Society Bengal*, lxxxiii, Part II, pp. 25-30 (1904).

(5) A Note upon the larva of *Ciana Crameri*. Read before the Linnean Society of London in April 1904 by Mr. E. P. Stebbing.

(6) A note upon the identification of the Insects reported by Mr. Lushington as injuring Swietenia Mahogani by Mr. E. P. Stebbing, *Indian Forester*, Scientific Papers, xxxi, pp. 75-76 (1905).

(7) The Volume on *Indian Buprestidae* by Mr. E. P. Stebbing. (*Under preparation*).

(8) Departmental Notes on Insects that affect Forestry, No. 3, by Mr. E. P. Stebbing.

(9) Manual of Indian Forest Zoology. A revision of a portion of the proof was undertaken.

(10) A "Note upon the Bee hole borer of Teak in Burma (*Duomitus ceramicus*)," by Mr. E. P. Stebbing.

(11) Insect life in India and how to study it, by Mr. E. P. Stebbing *Journal of the Bombay Natural History Society*, Volume xvi, p. 115 (1904).

VETERINARY SCIENCE.

BY

A. LINGARD, M.B., M.S., D.P.H.

*Imperial Bacteriologist to the Government of India.***Sero-therapy.**

In the Laboratory at Muktesar, during the year 1904-05, the preparation of anti-rinderpest and anthrax sera continued and quantities considerably in excess of former years were prepared.

In addition, Hæmorrhagic Septicæmia serum, which had been worked out in 1902 but could not be issued on account of the impossibility of obtaining fresh virulent material, was for the first time prepared in quantity and issued to Superintendents.

Further, Mallein, which was made at the Laboratory in 1899, but which had to be discontinued after the destruction of the Laboratory by fire, was again prepared and issued during 1904.

The following table gives the various quantities of different sera, etc., prepared and issued during the 12 months under review, together with the increase, comparing it with the quantities issued during the previous year :—

Name of sera.	Quantity prepared.	Quantity issued.	Increased manufacture as compared with last year.
	c. c.	Doses.	Doses.
Anti-Rinderpest serum	813,352 or 151,855 (doses.)	} 130,810	29,794
Anti-Anthrax serum	137,355 or 27,471 (doses.)		
Hæmorrhagic Septicæmia serum . . .	15,665 or 3,135 (doses.)	...	...
Mallein	1,514 (doses.)	675	...

During the year 590 outbreaks of Rinderpest were dealt with and 56,483 animals were immunized with serum by the "serum alone" method. Of this number, after injection, 263 succumbed, representing a mortality of 0.46 per cent.

One hundred and eighty-seven (187) outbreaks of Anthrax were dealt with and 21,287 animals were immunized with the anti-Anthrax serum. Not a single death followed the inoculations.

With regard to the use of Hæmorrhagic Septicæmia serum in the field, satisfactory reports have been received and the demands for it are increasing daily.

The utility of the various kinds of sera has been officially recognised, as conferring considerable benefit on the agricultural community; and each year sero-therapy in India is gaining ground and is generally being appreciated by the zemindars.

BACTERIOLOGY.

Rinderpest.—Experiments were initiated and continued with a view to the production of a prophylactic capable of conferring immunity on bovines, etc., without the necessity of hyper-immunization with large quantities of blood. When satisfactory results have been obtained, the same will be communicated to the Government.

Dry Serum.—The utility of serum in dry form was tried in the field and results were satisfactory. The advantage in favour of dry serum is that it can be distributed in much smaller bulk, but as no antiseptic can be added to this in dry form, the powder must be used within 24 hours after solution has been made. Probably the dry form can only be used in this country under the direct supervision of Superintendents. The greatest use of this dry serum will most probably be found to be in the case of expeditions, military or otherwise, where large numbers of transport animals are employed.

Further, such expeditions carrying dry serum with them might have an opportunity of treating the cattle of people in whose territory they happened to be passing through or visiting; and by such demonstrations their sojourns might be more acceptable and political relations with such people facilitated. At the same time, should arrangements

be made by Government with any other foreign country to supply them with any particular serum or sera prepared at Muktesar, the dry material would be the best form for transmission to them.

Rinderpest in Camels.—The results of experiments proved that camels were susceptible to inoculated bovine Rinderpest and *vice versa*. As a rule, the disease was of a mild type and recovery followed in each case.

Pyroplasmosis Trypanosomiasis and Malignant Œdema in Cattle.—These diseases are only of occasional prevalence and will be dealt with in detail as opportunity occurs. Much work has already been done with regard to the above-mentioned diseases, and special reports dealing with each individually will be submitted in due course.

Surra.—The different questions as suggested in the programme of work for the past year have been dealt with *seriatim*, and considerable progress made in the various lines of research, which are still being continued.

It is hoped that the report on Trypanosomiasis in camels will be submitted at the close of the present official year. Short notices concerning the advancement made with regard to the various questions respectively taken in hand have been recorded in the Annual Report for 1904-05.

Dourine.—A full and detailed account has been published with regard to this disease in various breeds of horses, etc., and material is now accumulating for a further report to be submitted in the near future.

Training of Officers and Veterinary Assistants.—Four officers of the Army Veterinary Department and Civil Veterinary Department attended post-graduate classes during June to September inclusive, and in addition 67 Veterinary Assistants were instructed in the various practical and theoretical methods of inoculation and serum therapeutics.

Examination of Specimens.—Reports were forwarded to the officers concerned with regard to 124 specimens of different kinds of pathological material received at this Laboratory for microscopical examination and diagnosis during the year.

During the year, the Imperial Bacteriologist published:—

- (i) Report on the preparation of Rinderpest protective serum.

- (ii) Report on Dourine in different breeds of equines.
- (iii) Annual Report.
- (iv) Observations on the Filarial Embryos found in the general circulation of the Equidæ and Bovidæ and their probable pathological significances. Fasciculus I. Bursati (published by Messrs. Adlard and Son, London).

The following papers were published by the Imperial Bacteriologist in the Scientific Journals :—

- (a) A short account of the various trypanosomata found to date in India in the blood of some of the lower animals and fish. (I. M. G., Vol. xxxix, No. 12.)
- (b) The giant trypanosoma discovered in the blood of bovines (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxv).
- (c) Can the Piroplasma Bigeminum find a habitat in the human subject? (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvi).
- (d) The trypanosoma of Dourine and its life-history. (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvii).
- (e) Resistance against Rinderpest and other infectious diseases conferred by the subcutaneous injection of certain bile products, and also by the injection of substances prepared from animal testes and the seeds of plants. (Centralblatt für Bakteriologie, Parasitenkunde und Infek: Originale, Band xxxvi).

- (f) A preliminary note on Piroplasmosis found in man and in some of the lower animals. (I. M. G., Vol., No. xxxix.)

Papers published by the Assistant Bacteriologist during the year :—

- (a) A trypanosoma found in the blood of cattle. (By Captains Durrant and Holmes). Journal of Comparative Pathology and Therapeutics, Vol. xvii, page 209.
- (b) Evolution of the Trypanosoma Evansi.—Journal of Comparative Pathology and Therapeutics, Vol. xvii, page 210.

- (c) Some diseases complicating Rinderpest among cattle in India.
—Journal of Comparative Pathology and Therapeutics,
Vol. xvii, page 317.

Other papers published bearing on such diseases:—

- (a) The prophylactic treatment of Rinderpest by means of preventive inoculation, more especially considered in regard to the conditions prevailing in India. (By Captain G. K. Walker.) Comparative Pathology and Therapeutics, Vol. xvii, page 326.
- (b) "On Dourine." (By Captain F.S.H. Baldrey.) Comparative Pathology and Therapeutics, Volume xvii, page 1.
- (c) "Dourine and Surra." (By Major H. T. Pease.) Veterinary Journal, November, 1904.
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**PROGRAMME OF WORK OF THE VARIOUS SCIENTIFIC DEPART-
MENTS FOR THE YEAR 1905-06, AS APPROVED BY THE
BOARD ON 24TH MARCH 1905.**

I. Meteorological Department.

As the two gazetted assistants whose appointment was sanctioned in January 1904 have only recently joined the Department, several items of last year's programme could not be carried out and are accordingly repeated below: as much as possible of the preparatory work has been done.

Daily Forecast, Storm and Flood warning.—It is intended to begin the formation of a classified file of maps on a reduced scale illustrating the principal types of weather: series of charts of all important storms or remarkable disturbances will be inserted for ready reference in determining the probable developments of the weather, and the areas to which storm or flood warnings should be sent.

Study of the Indian monsoon area and seasonal forecasting.—The materials that have been examined during the year support the view that abnormalities in the Indian rainfall are due to unusual elements in the larger circulation of the atmosphere, including deflections in a vertical as well as a horizontal direction. There are decided suggestions of relationship between the conditions in Siberia and the Indian Ocean with those of our monsoon, but the data are still being collected and much work has yet to be done before any results can be regarded as established.

It is now clear that sufficient readings are not available for the publication of a daily map of the whole monsoon area, including Southern Asia, East Africa and Australia: maps of this region showing the monthly departures from normal of pressure and temperature will accordingly be made.

Pilot Charts.—Considerable progress has been made in the preparation of an atlas of monthly charts of the Indian Ocean for use by captains of vessels.

Study of the upper atmosphere: Balloons.—It appears unlikely that over large parts of India an india-rubber balloon sent up with self-registering apparatus would be found and returned to Government after reaching the earth. Hence it is proposed to begin with paper balloons which will be filled with hydrogen and sent up in fairly calm weather. From observations made with two theodolites about two miles apart it should be possible to deduce the wind velocity at different elevations.

Kites.—If the necessary apparatus arrives in time operations will begin, probably at Kurrachee, during the approaching monsoon season. After preliminary experience with hand-winding gear has been obtained, an oil motor will be employed.

Solar Radiation.—Observations made with black-bulb thermometers have long been regarded as unsatisfactory for the purpose of studying variations from year to year in the quantity of heat given off by the sun, and a beginning has been made at Calcutta with a Calendar platinum sunshine-recorder which promises to give much more reliable results. Instruments of the latter type should be started in one or two of our other observatories under suitable conditions, and a satisfactory method of standardising the apparatus from time to time should be obtained and adopted.

Atmospheric Electricity.—Apparatus for measuring the potential gradient of the air by means of a water dropper has been established at Calcutta, as well as apparatus for ascertaining the rate of dissipation of a charge. It is intended to make a study of the differences found between the wet and the dry periods of the year.

Magnetism.—Owing partly to architectural difficulties and partly to slight changes in one of the new magnets, it has been found necessary to continue for another year the duplicate series of observations for the purpose of comparing the conditions at Alibág with those at Colába. The former station is that to which the magnetic observations will shortly be transferred, in view of the approaching establishment of electric tramways at Bombay.

Arrangements have also been made for a discussion of the Colába magnetic observations of the past 60 years.

Astronomy.—The appointment of an assistant at Kodaikānal has been sanctioned, but the date of his arrival is doubtful.

The spectroscopic examination of spots and prominences has now become part of the routine work. The spectroheliograph has been erected and satisfactory photographs of the sun in monochromatic light have already been made with it.

Arrangements have been made for co-operating with the "Committee on Solar Research," a representative body of astronomers with Professor G. Hale as chairman.

2. Survey of India.

The special scientific work which will probably be undertaken by the Survey of India during 1905-6 is as follows:—

Magnetic Survey.—Colába Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work: observations will be taken at 24 Repeat Stations: and the preliminary field work will be extended over Assam and Burma.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M., and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

3. Geological Survey.

The following subjects will probably be undertaken:—

1. Investigation of the copper-sulphide belt of the Singbhum district.
 2. Survey of the auriferous gravels of the Upper Irrawaddy.
 3. Exploration of the Upper Chindwin Basin.
 4. Survey of unmapped areas in the Central Provinces.
 5. Continuation of mapping in unsurveyed parts of Central India and, in conjunction with it, a survey of the Aravalli series in the adjoining parts of Rajputana.
- Extension of survey work in progress in the Northern Shan States.

4. Botanical Survey.

I.—COUNTRY UNDER THE SUPERINTENDENT OF THE ROYAL BOTANIC GARDEN, CALCUTTA.

(a) *Bengal.*

It is proposed to utilise the agency of trained Lepcha collectors under the supervision of the Officer in charge of the Chumbi Valley Road Survey to collect in that valley, and it is hoped to be possible to send a European collector also for a short time. An endeavour will be made to adhere to the plan of working out for some one district in Bengal its flora as has been done for the Hughli, Howrah and Sundarbuns districts, but this will depend on whether a European collector will be available or not.

(b) *Assam and Burma.*

The same policy will be followed in prosecuting the systematic survey of Assam and Burma.

II.—SURVEY OF BOMBAY.

Professor Gammie, the Officer in charge of the survey of Western India, proposes during the year 1905-06 to continue special investigations on the Ghâts, some of the Deccan districts, Gujarat and, possibly, Sindh.

III.—SURVEY OF SOUTHERN INDIA.

The Government Botanist, Madras, will undertake during the year 1905-06 a tour in Travancore and a tour in the Ceded Districts. These tours were fixed for the current year 1904-05, but had to be postponed owing to the economic exigencies of the Madras Government. This programme has received the approval of the Board of Revenue, Madras.

IV.—ECONOMIC INVESTIGATIONS.

The only economic work which comes directly under the cognizance of the Director of the Botanical Survey is that done by himself in his capacity as Superintendent of the Royal Botanic Garden, Calcutta.

The Officiating Director proposes to take up and continue, as far as his other duties will permit, the study of the botanical classification of the various kinds of fibre-yielding plants grown in India. Those Indian fibres are also being studied by the Agricultural Department as field crops, while the commercial value of their produce is being investigated by the Reporter on Economic Products. The Economic investigations which form by far the greater part of the work of the other two officers of the Botanical Survey are directly instituted and controlled by their own Local Governments, and do not come under the cognizance of the Director of the Botanical Survey.

5. Agricultural Department.

1. Pusa Research Institute, Agricultural College and Experimental Farm.—Further progress will be made in establishing the Pusa Agricultural Research station. Some of the buildings are approaching completion. The existing staff of experts will be transferred there as soon as the quarters are ready, and the newly appointed Specialists will be instructed in their lines of work. The College and Laboratories will not be ready till 1906-07. The Farm buildings have been built and a substantial portion of the land has been broken up, but it has not yet been brought into a sufficiently good cultivable condition to admit of a comprehensive scheme of experiments during the coming year. The principal crops that will be grown are cotton, sugarcane, indigo, rice, tobacco, linseed, til, maize, wheat, gram, mustard, groundnut and fodder crops. In growing these crops, the main objects will be to determine:—

- (a) the effect of transferring varieties from district to district ;
- (b) the effects of different methods of cultivation, and the value of different manures ;
- (c) the effect of acclimatization upon indigenous and exotic varieties ;
- (d) improvement by cross fertilization and selection.

Crops that already have proved successful will be grown on a larger scale for seed distribution. The Java-Natal variety of indigo will thus be grown for seed distribution. The best varieties of sugarcane and rice grown in different parts of India will be tested for Behar A

number of varieties of American, Java and Sumatra tobaccos are under trial. An experiment will be tried in growing linseed for flax. A mulberry plantation has been started for experiments in sericulture. A commencement will be made with the vegetable plots and fruit orchards, where ultimately experiments will be made for improving the best varieties. The cattle-breeding farm for the Bengal breed has been started. An experiment is also being made with the acclimatization of Montgomery cattle for milch purposes. Fodder crops will be grown for the cattle, and attempts will be made to improve the pastures by the trial of several kinds of grasses.

2. Provincial Experimental Farms.—At all the provincial farms there are series of permanent experiments dealing with the trial of manures for various crops, irrigation, crop rotations, methods of cultivation, testing of varieties of crops and the like. In Bombay the number of experiment stations has been increased to nine, largely devoted to cotton, wheat, groundnut and juar. A systematic study of the varieties of some principal crops is in progress under Professor Gammie. The Poona Dairy Farm will be continued, including tests of the milking qualities of several breeds, and the comparative trial of various fodder crops. Many of the problems connected with sugarcane are under study at the Manjiri Farm. Experiments with the effluent of sewage passed through a septic tank are in progress at the sewage Farm, (1) to find out the best treatment for its purification; (2) to find out the manurial value of the effluent and the varieties of crops that can best be grown with it; and (3) to find out the area of land required to take the sewage from a given population. Problems (2) and (3) are practically solved. Experiments are in progress at the Botanical Gardens, Ganeshkhind, to test rubber, fibre and medicinal plants, and to improve and increase the yield of fruit trees. The Department of Agriculture in the United Provinces will pay special attention to the study of juar, irrigation wells and sugar manufacture. Cawnpore is the principal centre of experiments with wheat rust. In Bengal, attention is mainly devoted to rice, sugarcane, tobacco and potatoes. A special enquiry into the cultivation and manufacture of indigo is in progress in Behar under Mr. Bergthell, Bacteriologist. Another special enquiry is being conducted by Mr. Finlow, Chemist, into the cultivation and alleged deteri-

oration of jute. In the Punjab, wheat and cotton are the principal crops under investigation. A large seed farm will be started. The Madras farms are specially concerned with cotton, sorghums, sugarcane, tobacco and groundnut. The study of wild peppers will be taken up with reference to the pepper-vine disease. A survey of the cultivated plants has been started. Attention is being given to agave fibre plants. In the Central Provinces, the principal crops under experiment are cotton, juar, rice and wheat. The Assam Department is concerned mostly with potatoes, fodder crops, spices, drugs and tropical fruits. Experiments are also in progress for the introduction of European and other semi-temperate fruits.

3. Agricultural Chemistry.—The Agricultural Chemist to the Government of India will be employed mainly upon the investigation of the following problems:—

- (a) **Soils.**—The amount of readily available plant food in various Indian soils, with special reference to Dr. Dyer's method of determining the amount of readily available phosphate and potash, has been experimented upon in the Laboratory and the potculture house during the past year, and the subject will be prosecuted further in the current year.
- (b) **Rain-water, Dew and Drainage water.**—Specimens of these have been collected at Cawnpore and (of rain-water) at Dehra, and the quantity of combined nitrogen determined and reduced to pounds per acre. It is proposed to construct some drain-gauges at Pusa during the current year in order to supplement the Cawnpore records.
- (c) **Water in soils.**—An attempt will be made to obtain information regarding the nature of the movements of water in Indian soils both under crops and bare fallows. It is also proposed to keep a record of the actual amount of water in the soil at all depths down to 5 feet from the surface.
- (d) **Cyanogenesis in plants.**—It is proposed to prosecute an enquiry into the glucosides capable of yielding hydrocyanic acid, and more particularly into the poisonous qualities of sorghum, cassava, Rangoon beans, dal (*Dolichos Lablab*) and field peas.

(e) The analytical work regarding Indian food-grains and fodders and of samples of other products and manures will be continued.

(f) The enquiry into the sugarcane cultivation of the Central Provinces will be supplemented by the analysis of the juice of the different varieties. The results hitherto obtained show that the cane is undoubtedly poor in some parts.

4. **Mycology.**—The programme of work of the Cryptogamic Botanist to the Government of India is as follows:—

(a) It is proposed to continue the work connected with the rusts of wheat and barley. The experiments will mainly be made at Cawnpore (United Provinces), Hoshangabad (Central Provinces), and Lyallpur (Punjab), *first* to collect all the local varieties of wheat true to type, *second* to expose them to conditions favourable to rust by heavy irrigation, *third* to grade the varieties according to their rust-resistant quality, and *fourth* to raise rust-resistant varieties of good milling quality by hybridization.

(b) The study of the wilt disease of Arhar (pigeon-pea), and the pepper-vine disease, both of which are caused by the same fungus, will be continued with the object of discovering resistant varieties.

(c) Treatment of oat-smut with formaline and copper sulphate is being tested, and that of the two smuts of jwar common in India will be tried during the year.

(d) Groundnut disease requires further work which cannot be outlined until the results of this year's experiments are known.

(e) The green ear disease of bajra which is due to a new species of *Sclerospora*, and which is common in several provinces, will be studied, but is not likely to be fully worked out in the coming year.

(f) The coffee twig disease, which has recently appeared in South India, first in the Nilgiris and later in the Neliampatties, is at present under treatment experimentally. The results

- of the different methods tried should be known in coming year, and, if successful, treatment can be extended.
- (g) The cause of the *Casuarina* disease in the Ganjam plantation has recently been ascertained, and attempts will be made to prevent its extension.
 - (h) It is proposed to arrange for a local study in the coming year of a rice disease which is locally known as *Chatra*, and which is reported from several parts of Bengal.
 - (i) Work on sugarcane diseases, particularly redrot and smut, will be continued.
 - (j) A preliminary tour will be made in Assam to collect information regarding the fungus diseases prevalent in that province.

5. Entomology.—The Insectory, quarters and other buildings at Pusa will be completed, and crops will be grown for the study of insect pests and the methods of treatment. The Entomologist to the Government of India will carry out the following programme:—

- (a) The investigation of such crop pests as have not been worked out, and the value of remedies against such pests as have been already studied and will be found to occur at Pusa, will be carried out.
- (b) An attempt will also be made to deal with every pest for which remedies are already known, with a view to protecting crops and to determining how far and at what cost it is possible to check pests by means within the reach of the ordinary cultivator.
- (c) In addition there are the following enquiries; (1) the treatment of burrowing insects and white ants; (2) the value and scope of treatment with insecticides; (3) the use of light traps as indicators of approaching pests and as means of destroying flying insects; (4) the insect pests of cattle and domestic animals; (5) the value of trap plants, especially of maize and juari as a trap for moth-borer in sugarcane, and of *bhinda* for cotton pests; (6) the value of special means of increasing beneficial insects (parasites and

predators) which prey upon common pests, and (7), the relation between plant vigour and immunity to special classes of pests.

- (d) It has been arranged to train men in Entomology for Provincial Departments of Agriculture.
- (e) Arrangements have also been made for the issue of publications dealing with Entomology.
- (f) The systematic survey of the Insect Fauna of India will be continued, so far as the stress of other work permits.
- (g) A separate branch of work connected with sericulture will be started at Pusa.
- (h) A further trial of the South African locust fungus will be made at Pusa under the joint supervision of the Government Entomologist and the Cryptogamic Botanist.

6. Special Investigations.—Amongst special investigations to be carried out the following may be mentioned :—

- (a) the use of crude nitre as a manure for certain crops ;
- (b) the use of *sitta* (impure salt) as a cattle food ;
- (c) the use of mineral fertilizers ;
- (d) the cultivation of various fibre plants under varying conditions of soil and climate, and the profitable extraction of fibre therefrom ;
- (e) The experiment of crushing varieties of cotton seed, sent to Hull to test the value of the oil and cake.

The practical training of overseers and fieldmen on the best-managed existing farms and at Pusa will also receive attention.

7. Cotton.—As special attention is being given to cotton by the Imperial Department and some of the Provincial Departments, this subject is treated in a separate paragraph. The botanical examination and classification of all existing varieties, both wild and cultivated, has been completed by Professor Gammie, and the results will shortly be published. The introduction of better varieties and improved methods of cultivation is in progress, the principal lines of work being :—

- (1) selection of individual plants, some for quality of fibre, others for largeness of yield ;

- (2) crossing of one indigenous variety with itself or with a second indigenous variety ;
- (3) crossing of indigenous varieties with exotics ;
- (4) introduction and acclimatization of exotic varieties ;
- (5) distribution of sound and pure seed.

Some hybrids obtained at Surat and the Central Provinces show promising prospects, but selection must be made for two or three years longer in order to fix the type. Some new American varieties have been grown with fair success in Dharwar, but require acclimatization. The trial of Egyptian cotton has given very promising results in Sindh under perennial irrigation. These experiments will be largely extended both on the Government farm and by the distribution of seed to cultivators. Selection of seed of indigenous varieties has not given much result in the United Provinces, but the work in that province will be continued (1) by selection of seed mainly for the improvement of the yield, (2) hybridization, and (3) the trial of the variety known as *bani* cotton. Acclimatized Americans show some promise around Cawnpore. In Madras efforts are being made to test and separate the different varieties of cotton grown in mixtures. Cross-breeding between varieties *inter se* will be started. Messrs. Shaw, Wallace & Co. are making extensive trials of tree-cottons in Bengal. The Punjab Department are obtaining promising results with American varieties, both new and acclimatized. Seed of tested varieties will be distributed to cultivators for experimental trial. In the Central Provinces, experiments are in progress (1) to improve indigenous varieties by seed selection and hybridization; (2) to test acclimatized Americans and arrest their deterioration by cross-breeding with new Americans, and (3) to introduce improved methods of cultivation. In all provinces attempts are being made to obtain, for distribution to cultivators, improved seed of indigenous varieties, by collecting the best samples growing in the cultivators' fields, and brought to the principal cotton markets. Endeavours are also being made to induce the owners of ginning factories to set aside the best supplies and gin them separately for subsequent seed distribution. Proposals will be submitted to Government for (1) the appointment of a special cotton expert to the staff of the Inspector-General of Agriculture to inspect and co-ordinate the

work in all provinces; (2) the strengthening of the expert staff in each province in order that they may be in a position to deal adequately with cotton problems; (3) the establishment of three large cotton farms, one farm in the Surat-Broach cotton tract of Bombay for the improvement of the indigenous variety by selection of seed; one farm in a suitable irrigated tract of the Punjab for the trial of exotics; and one farm in the Central Provinces for the dual purpose of (1) the improvement of the coarse *jari* variety by continuous seed selection, and (2) the improvement of the fine *hani* variety by seed selection, mainly to improve the yield.

8. Irrigation.—Experiments will be started in all provinces to give effect to the recommendations made by the Irrigation Commission in Chapter XI of their report.

9. Publication.—The important subject of Publications will also be taken up, the present proposals being:—

- (a) an extended issue, by the Imperial and Provincial Departments, of leaflets in the vernacular for distribution to cultivators;
- (b) the issue of bulletins, by the Imperial and Provincial departments dealing with detailed experiments when they become sufficiently advanced to yield definite results;
- (c) an annual report of the experimental work of each farm for distribution to persons interested therein;
- (d) the issue of a quarterly agricultural journal, edited by the Pusa staff, for the use of agriculturists and of the general reader interested in Agriculture, and
- (e) scientific memoirs, to be issued from the Pusa institute, for papers of a scientific or technical nature.

6. Forest Department.

1. Experiments will continue to be made with the preparation of various tannin extracts, more especially to ascertain the best method by which these extracts can be decolorised so as to render them of more marketable value.

2. It is hoped that the services of an expert will be obtained to conduct practical experiments with reference to the manufacture of wood pulp.
3. Investigations will be made by the Forest Entomologist into the injuries to forest growth caused by various insect pests and the best means to adopt to reduce the damage caused by them.
4. The collection of specimens of timbers and other products will be continued for supply to the Director, Botanical Survey, and Reporter on Economic Products.
5. Seeds of several important indigenous species will be collected and sent to various British Colonies.
6. Further collection and analysis of the latices of rubber-producing species will be made.

7. Economic Products Department.

A classification of the resinous substances known in commerce as "dammar" is being carried out with regard to their sources and chemical properties. The odoriferous gum resins of the myrrh tribe are being investigated, and fresh samples are being collected for this purpose from Bombay.

Experiments with the latices of india-rubber trees and the valuation of rubbers from different economic sources are being conducted in conjunction with the Imperial Institute. The Conservators of Forests of the Pegu and Tenasserim Circles, Burma, are experimenting with the tapping of *Parameria* trees: and the rubbers, collected under different conditions, will be chemically examined by Professor Dunstan.

The enquiry into the origin and value of Indian fibre plants is proceeding. This enquiry deals with the proposal to estimate the cellulose content of such materials as are considered suitable for paper-making. Rattans (*Calamus* spp.) and mat-making grasses are being collected.

The survey of Indian-grown cottons will be continued during the year, in communication with the Director of the Botanical Survey and the Agricultural Department.

The following medicinal substances are proposed for investigation by the Indigenous Drugs Committee during the coming year:—*Adhatoda* *Vasica*, *Alstonia scholaris*, *Andrographis paniculata*, *Cæsalpinia Bondu-*

cella, *Calotropis procera*, *Embelia Ribes*, *Ipomœa hederacea*, *Picrorhiza Kurroa* and *Podophyllum Emodi*. A large supply of aconite roots from Sikkim has been supplied to Professor Dunstan to enable him to continue his researches in the aconite alkaloids, and the subject will continue to receive attention during 1905-1906.

Samples of cutch and catechu are under investigation by the Curator of the Industrial Section.

The enquiries into the forms of juar and of yams (*Dioscorea*) which have nearly reached completion will, it is hoped, be finished, and the study, from the economic point of view, of other field and garden crops for which materials are accumulating will be prosecuted. Assistance in this direction has been promised from many parts of India, including the province of Mysore through its Agricultural Chemist. An extensive list of foods used in India in times of famine and of scarcity is about ready for publication.

A large and representative collection of pottery clays has been brought together and despatched to the Imperial Institute for chemical and technical examination: on receipt of the reports of experts steps will be taken to apply the results for economic and industrial purposes through this Department.

8. Indian Museum, Natural History Section.

The two undertakings that will chiefly engage the attention, in addition to the ordinary routine, of this Department during the year will be—

- (1) continuation of investigation upon the marine fauna in collaboration with the Marine Survey Department;
- (2) continuation of investigation upon the insect fauna in co-operation with the Government Entomologist and with certain volunteers in Assam.

9. Civil Veterinary Department.

1.—(a) **Rinderpest.**—Further experiments with a view to raise the potency of the anti-rinderpest serum, to improve the methods of preparing, collecting and bottling. Apparatus for sterile decanting, for

defibrinating the blood, and for evaporating the serum to reduce its bulk, will be tested.

The serum will also be prepared in dry form and the utility of this method will be tried.

(*δ*) Rinderpest in camels; enquiry will be continued.

II.—(a) Piroplasmosis, (b) Trypanosomiasis, (c) Malignant Oedema.—These three diseases have been observed at the Laboratory appearing as secondary diseases to Rinderpest in cattle. These diseases will be further investigated as to their prevalence, the course they run, and their effect as a disease secondary to Rinderpest.

III.—Surra.—Work will be carried out on the following lines:—

- (1) to attempt a prophylactic or curative serum;
- (2) to attenuate the *Trypanosoma* by means of cultures;
- (3) to attenuate the *Trypanosoma* by passing it through the body of animals other than equines;
- (4) Surra in camels has now been under observation for several years, and a separate report on the subject will be forwarded to Government, when results are sufficiently advanced to permit of so doing.

IV.—Anthrax.—Further efforts will be made to raise the potency of the anti-anthrax serum, and investigation will be made with a view to discover a method of conferring a more lasting immunity.

V.—Hæmorrhagic Septicæmia.—The further elaborating of an anti-hæmorrhagic Septicæmia serum.

VI.—Charbon Symptomatique.—The working out of a protective serum.

VII.—Dourine.—Further observations will be made on the special features of this disease in India, and a report of the result of investigation published.

VIII.—Glanders.—Mallein will be prepared.

IX.—It is also proposed to prepare Tuberculine, Tetanus anti-toxin and anti-streptococci serum, as opportunity arises.

X.—A post-graduate class in Bacteriology and Pathology for the Officers of the Army and Civil Veterinary Departments will be continued.

XI.—The class for Veterinary Assistants will be continued as during previous years.

XII.—Material sent to the Laboratory for purposes of diagnosis will be reported on.

APPENDIX.

Economic Investigations conducted at the Imperial Institute.

BY

W. R. DUNSTAN, M.A., L.L.D., F.R.S.

Director of the Imperial Institute.

The Scientific and Technical Department of the Imperial Institute is in receipt of a grant, the present amount of which is £200 per annum, for the purpose of conducting for the various departments of the Government of India such scientific and technical investigations of economic importance as are best pursued in London, either on account of their special character and complexity or on account of the desirability of the results being communicated to manufacturers and commercial experts with a view to technical trials and commercial opinions and valuations being obtained. The Director of the Imperial Institute is a member of the Committee appointed by the Royal Society to advise the Government of India on its scientific and economic work. The channel of communication with the Imperial Institute is through the Office of the Reporter on Economic Products. The following is a brief account of the more important work which has been conducted at the Imperial Institute during the year ended the 30th September 1905.

Drugs.—Aconites.—The investigation of the poisonous alkaloids of the Indian aconites has been continued during the year and has furnished important results relative to the use of the different species in medicine. Two new alkaloids, which have been named indaconitine and bikhaconitine, have been discovered in *Aconitum chasmanthum* and *Aconitum spicatum*, respectively, and a paper giving an account of the pharmacology of these substances was communicated recently to the Royal Society by Professors Cash and Dunstan (Proceedings of the Royal Society, 1905). Papers dealing with the chemistry of the new alkaloids will be communicated to the Chemical Society at an early date.

Solanaceous drugs.—The enquiry into the alkaloids of the Indian *Hyoscyamus muticus* has been extended to the other species of this

genus which occur in India and also to the Indian *Daturas*. Specimens of *Hyoscyamus niger*, *Hyoscyamus reticulatus*, *Datura Stramonium*, and *Datura fastuosa* are at present under investigation with the object of determining the amount and nature of the alkaloids which they contain and their suitability for use in medicine or as commercial sources of the alkaloids.

Opium.—The question of the purity of the opium alkaloids manufactured at Ghazipur has received further attention during the year. A report has been furnished upon one set of samples, representing a commercial consignment of morphine hydrochloride and codeine forwarded to London for sale, and another set of similar samples is under examination at present. In connection with this work the Indian Government has referred to the Imperial Institute the question of the improvement of the manufacturing processes at present employed at Ghazipur, with the object of obtaining alkaloids which will conform to the requirements of the British Pharmacopœia. This enquiry is now proceeding and samples of the waste opium used for manufacturing purposes at Ghazipur and of the mixture of crude morphine and codeine hydrochlorides have been received for use in the investigation.

Strychnos species.—In continuation of the enquiry with regard to the constituents of the various species of Indian *Strychnos*, samples of *Strychnos Nux-Vomica* and *Strychnos potatorum* have been received for examination.

Rubber.—A number of specimens of rubber and rubber latices have been received from India during the year for investigation in continuation of the general enquiry into these products initiated several years ago. Amongst these were two specimens of the rubber of *Ficus elastica*, one from the Charduar plantation and the other from Parlakimedi in the Madras Presidency, and it was found on examination that the material from Charduar contained an unusually large amount of resin, 19·2 per cent., whereas a much lower percentage, 7·8, was present in that from Parlakimedi. For comparison with these figures it may be noted that a sample of *Ficus elastica* rubber which was recently received at the Imperial Institute from the Federated Malay States only contained 3·9 per cent. of resin. The large percentage of resin in the Charduar sample is important, as it would affect adversely the market

value of the rubber and it would be interesting to determine whether this feature is characteristic of the product yielded by the trees in Assam or is only accidental.

The Conservator of Forests, Assam, forwarded a consignment of the bark and leaves of *Ficus elastica*, in order to determine whether there was any possibility of extracting rubber from the material, large quantities of which are obtained in the tapping operations. The results of the investigation showed that it was very improbable that the material could be utilised in the manner suggested.

Reports have also been furnished upon the quality of the products furnished by the rubber-like latices of *Ficus comosa*, *Ficus indica*, *Ecdysanthera micrantha* and *Parameria pedunculosa*, and a specimen of the latex of *Parameria glandulifera* is at present under investigation. Of these *Ecdysanthera micrantha* and *Parameria glandulifera* yield marketable rubber, whilst *Parameria pedunculosa* demands further investigation.

Fibres—*Tacca fibre*.—Two samples of this fibre were examined and submitted to commercial experts with the object of ascertaining their suitability for use as a braiding material. It was found that one of the samples was well suited to the requirements of the London market, whilst the other, although not of the usual character, might possibly meet special needs.

Vegetable flosses.—An investigation of the flosses or so-called "silk cottons" of *Cochlospermum Gossypium*, *Calotropis gigantea* and *Calotropis procera* was carried out in order to determine the quality and value of these materials. The results showed that, on the whole, the Indian flosses were inferior to Java "kapok," but that they would be readily saleable at lower rates. An account is given in the report of the various purposes for which these products are utilised.

Agave fibres.—Two samples of Agave fibre, one of which was derived from *Agave rigida*, and the other from a species, the botanical identity of which had not been completely established, were submitted to chemical examination and comparison with other specimens. It was found that these fibres, although of fair quality, were capable of considerable improvement, and a recommendation was made that greater

care should be exercised in their extraction and preparation for the market.

Furcraea gigantea.—The examination of a sample of *Furcraea gigantea* fibre from Sambalpur Jail was carried out by the usual methods, and the results were compared with those furnished by other specimens of this fibre. It was shown that this sample was somewhat inferior to the other specimens, and it was demonstrated that this was largely, if not entirely, due to defective preparation.

Girardinia heterophylla.—A small sample of the fibre of *Girardinia heterophylla* from Calcutta was submitted to examination. The result showed that this fibre possesses valuable properties and is remarkable especially for its ability to withstand the action of alkali, its richness in cellulose, and the length of its ultimate fibre (6–20 inches). It is highly probable that, if this product could be prepared on a commercial scale, it might take a high position among textile fibres.

Nannorhops Ritchieana.—A sample of fibre from the leaves of a dwarf palm, *Nannorhops Ritchieana*, has been received from the Punjab, and is at present under investigation.

Aloe fibre from Madras.—Six samples of fibre, including specimens of *Agave americana*, *Agave rigida*, *Agave vivipara* and *Furcraea gigantea* have been forwarded from Madras by the Agri-Horticultural Society, and are at present under investigation. An interesting point raised in this enquiry is the influence of the elevation at which the plants are grown on the strength and other qualities of the fibre.

Tanning Materials and Dyestuffs.—A method for the preparation of tanning extracts from the barks of *Shorea robusta* and *Terminalia tomentosa*, which are at present waste products in India, has been devised and communicated to the Forests Department. This process obviates the production of the dark purple tints usually shown by leather tanned with these barks. The suggestion has been made to the Forests Department that the tanning extracts might be prepared in India by this process.

By means of the same process it has been found possible to prepare a tanning extract from Indian Kino, which yields leather similar in

character to that produced by the highly-esteemed wattle barks of Australia and Natal. It remains to be seen whether Kino can be produced cheaply enough to permit of the manufacture of tanning extracts from it.

A sample of tanning extract prepared in India from the bark of *Ceriops Candolleana* was examined and found to be of poor quality, and quite unsuitable for use for tanning purposes.

Arrangements have been made with Mr. A. G. Perkin of Leeds to examine the constituents of the Indian dyestuffs *Onosma echioides*, *Baccaurea sapida*, *Thespesia Lampas* and *Hibiscus Sabdariffa*. He has ascertained that *Thespesia Lampas* contains the well known dyestuff *Quercetin* and *Hibiscus Sabdariffa* the colouring matter *Gossypetin* identical with that present in the flowers of *Gossypium herbaceum*. *Onosma echioides* contains a very small quantity of colouring matter, and its investigation has been delayed owing to the difficulty of accumulating sufficient material for this purpose. *Baccaurea sapida* appears to contain no colouring matter.

Fodders and Foodstuffs.—Samples of the beans of *Phaseolus lunatus* and of immature plants of *Sorghum vulgare*, grown in India, have been chemically examined. The former was shown to yield small quantities of acetone and hydrocyanic acid when ground in contact with water, and therefore the beans probably contain the glucoside *phaseolunatin* obtained from the wild *P. lunatus* of Mauritius (Dunstan and Henry, Proc. Roy. Soc., 1903, 72, 285). Of the two specimens of immature *Sorghum vulgare* examined, only one yielded hydrocyanic acid in small quantity. Further specimens of younger plants have been asked for with a view to ascertaining whether the plant is richer in the glucoside *dhuririn* at earlier stages of its growth as is the case with *Sorghum vulgare* in Egypt (compare Dunstan and Henry, Phil. Trans., 1902, 1983B, 399).

Reference may also be made to the investigation of Cassava (*Manihot utilissima*) now being carried on with specially prepared material supplied from the West Indies. It has been definitely established that prussic acid does not occur free in cassava as has generally been supposed but in the form of a glucoside. Some progress has been made in determining the constitution of this glucoside.

A careful comparison of Indian and Chinese teas is being made at the request of the India Office, with a view to ascertaining whether there is any actual foundation for the belief occasionally expressed in this country that Indian teas are inferior to Chinese teas in certain respects.

Samples of coffee obtained (a) from unmanured plants and (b) from manured plants in Mysore are being examined with a view to determining the influence, if any, of manuring on the composition of the coffee berries.

Turpentine Oil and Resin.—An enquiry is in progress with regard to the composition and properties of Indian turpentine oils and resins derived from *Pinus Khasya*, *Pinus Merkusii*, *Pinus longifolia* and *Pinus excelsa*. Reports on this subject have already been issued, and the work will be continued on the receipt of further samples from India.

Minerals.—A number of samples of graphite from the Chhatisgarh District of the Central Provinces were analysed and shown to be of poor quality and small commercial value, owing to their containing much nongraphitic material.

At the request of the Geological Survey, the constituents of a large number of Indian coals have been determined. This work is supplementary to the analyses included in Professor Dunstan's Report on Indian Coals made in 1903, and completes these by the inclusion of determinations of the quantities of phosphorus present on which the value of the coal for metallurgical purposes chiefly depends.

Analyses are now being made, also for the Geological Survey, of a large number of samples of manganese ores, laterites and pottery clays, chiefly with a view to ascertaining their technical and commercial value.

The following are the titles of the reports forwarded to India from the Imperial Institute during the year (1904-1905):—

Report on the utilisation of the Barks of *Shorea robusta* and *Terminalia tomentosa* as tanning materials.

Report on Graphite from the Chhatisgarh District of the Central Provinces of India.

Report on a sample of Tanning Extract prepared in India from the bark of *Cerriops Candolleana*.

Report on a sample of fibre of *Girardinia heterophylla* from India.

Report on a sample of *Furcraea gigantea* fibre from India.

Report on two samples of Agave fibres from India.

Report on a series of Indian Vegetable Flosses.

Memorandum on the utilisation of Indian Tacca Fibre.

Report on a sample of Rubber derived from *Ficus elastica* grown at Parlakimedi, Ganjam District, Madras.

Report on the chemical examination of immature plants of *Sorghum vulgare* (*Andropogon Sorghum* Hack) grown in India.

Report on a sample of rubber derived from *Ficus elastica* grown in the Charduar Plantation, Assam.

Report on the extraction of rubber from the bark and leaves of *Ficus elastica*.

Report on a sample of the dried fruits of *Zizyphus sativa* (*Zizyphus vulgaris* Lam.) from India.

Report on the chemical examination of the beans of *Phaseolus lunatus* grown in India.

Report on the latices of *Ecdysanthera micrantha* and *Parameria pedunculosa* from Burma.

Report on the latices of *Ficus comosa* and *Ficus indica* from India.

Report on the utilization of kino as a tanning material.

At the close of the year the following investigations were in progress:—

Leaves of *Baccaurea sapida*, flowers of *Thespesia Lampas*, roots of *Onosma echiioides*, flowers of *Hibiscus Sabdariffa*, Indian Aconites, Alkaloids manufactured at Ghazipur, Manufacture of Opium alkaloids from waste Opium, *Hyoscyamus niger*, *Hyoscyamus reticulatus*, *Datura Stramonium*, *Datura fastuosa*, Latex of *Parameria glandulifera*, Fibres of *Nannorhops Ritchieana*, Agaves and *Furcraea gigantea*, Comparison of Indian and Chinese teas, Indian turpentine, Manganese ores, laterites and pottery clays.

Summaries of the more important of the Reports included in the foregoing list have been published during the year in the "Bulletin of the Imperial Institute," which is now issued quarterly in a new form.

During the year the following articles prepared by the Staff of the Scientific and Technical Department of the Imperial Institute, and relating especially to Indian natural products, have been published in the "Bulletin of the Imperial Institute:"—

Sisal Hemp in India Volume ii, page 260.

Mining and preparation of mica for commercial purposes. Volume ii, page 278.

Manufacture of coke in India Volume ii, page 291.

Production of Manganese ores in India Volume iii, page 81.

The supply of precious stones Volume iii, page 86.

The "Bulletin" circulates in the Colonies and in Great Britain, and contains special articles on subjects of economic importance in addition to reports of the investigations conducted at the Imperial Institute. Its columns are open to articles on similar subjects from those connected with Scientific Departments in India and the Colonies, and the Director will welcome any contributions from India.

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Bengal Office.

- (1) Bengal Daily Weather Report and Chart.
- (2) Monthly rainfall tables and summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly abstracts of the Bombay observations (Bombay Gazette).

Madras Office.

- (1) Madras Daily Weather Report and Chart.
- (2) Monthly rainfall tables (Madras Gazette).

Allahabad Office.

- (1) Monthly Weather Summaries (United Provinces Gazette).
- (2) Annual Summary.
- (3) Monthly rainfall tables (United Provinces Gazette).

Lahore (Simla) Office.

- (1) Monthly Summary } of Punjab weather.
- (2) Annual Summary }

III.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica, arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVI, including the larger papers on geological subjects.

Records, Vols. I—XXXII, including the shorter papers and annual Reports from 1868 to 1904, sold in parts, price one rupee each.

Manuals, Guides, and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta. Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the *Memoirs*, Vols. I—XX, and to the *Records*, Vols. I—XXX, have been printed for sale.

IV.—SURVEY OF INDIA.

- (1) Annual General Report.
- (2) Professional Papers.

V—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

- (1) Annual Report of the Botanical Survey of India.
- (2) Records of the Botanical Survey, Vols. I—III, No. 2, and Vol. IV, Nos. 1—3.
- (3) Annual Report of the Royal Botanic Garden, Calcutta.
- (4) Annals of the Royal Botanic Garden, Calcutta, Vols. I—X.

VI.—DEPARTMENT OF AGRICULTURE.

- (1) *Annual Report*.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology and the like).
- (2) *The Agricultural Journal of India*.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.
- (3) *Scientific Memoirs of the Department of Agriculture*.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological and the like.

- (4) *Bulletins*.—An occasional publication containing information on agricultural matters of a temporary nature.
- (5) *Leaflets*.—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VII.—FOREST DEPARTMENT.

- (1) *Review of Forest Administration in British India* by the Inspector General of Forests, (issued annually).
- (2) *Annual Progress Report of Forest Administration in each Province*. Issued by the Local Governments annually.
- (3) *The Indian Forester*.—A monthly journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal published monthly.
- (4) Bulletins are published from time to time.

VIII.—ZOOLOGICAL DEPARTMENT.

- (1) Annual Report.
- (2) Monographs, appearing at irregular intervals.

IX.—CIVIL VETERINARY DEPARTMENT.

- (1) Annual Report.



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